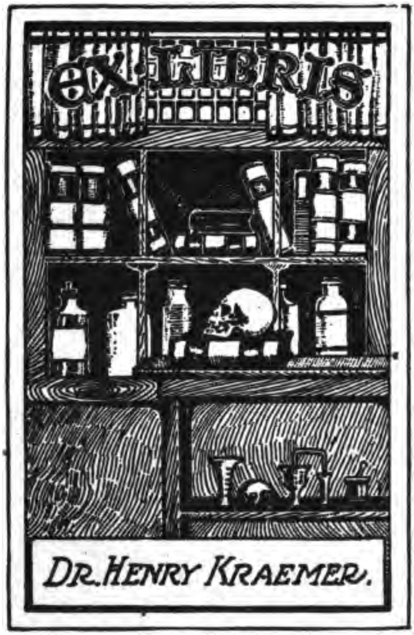
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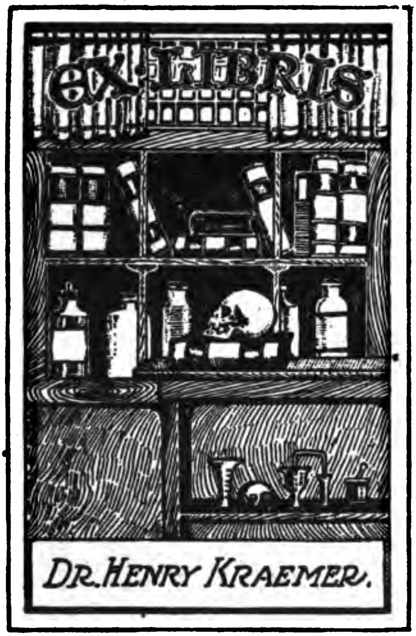
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# GENERAL

# VEGETABLE PHARMACOGRAPHY

BY

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# PREFACE.

This booklet is written for students of pharmacography, hoping that the suggestions given may serve as a preparation and an aid to the study of vegetable drugs in both the crude and powdered forms. Chapters I and II are intended to give the student a more correct and comprehensive idea of the evolution and relationship of the sense organs and to indicate the functional limitations of the sense organs and the dependent limitation of learning. It is assumed that the student entering upon the work of pharmacography has at least a knowledge of elementary physiology in order that he may comprehend the functional activities of the sense organs and that he may understand the special physiology of sensations as it applies to the examination of vegetable drugs and related substances.

A popular notion prevails that our knowledge of things is absolutely reliable and unchangeable. This is in no wise true as will be explained; yet it is hoped that this information will not develop undue skepticism in the minds of students as to the true significance and value of sense perception. Much of our information regarding the senses, standards of comparison, etc., is very meager and requires further confirmation based upon careful investigation. This is particularly true of the sense of smell.

As the title implies this book is intended to serve as a student's guide to the general pharmacography of vegetable drugs. It is a supplement to any one of the existing textbooks on pharmacognosy as none of them contains any reference to a general survey of the subject. The contents

of this book should therefore be considered before taking up the special study of vegetable drugs.

The limited treatment of the subject-matter is primarily due to the deficiency in information. In some instances authoritative information is entirely wanting and again differences of opinion are so marked as to render the subject impossible of suitable presentation in a text-book intended for students.

ALBERT SCHNEIDER.

Chicago, September, 1900.

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# GENERAL INTRODUCTION.

All knowledge is obtained directly or indirectly through the activities of the sense organs. We recognize and identify the multitudinous substances with which we come in daily contact by their properties as they are revealed through the senses. We may know only such properties as are capable of stimulating the senses to functional activity. Five separate and distinct senses and sense organs are usually recognized but the properties of each and every substance do not stimulate all of the senses. If the property of the substance acts only upon the sense of smell, as in the case of marsh gas, the remaining four senses are of no practical value as far as the recognition and identification of that particular substance is concerned. If the properties act only upon the sense of taste, as solutions of various salts, sugar and some acids, we may not smell, see or feel them. As a rule, however, our knowledge of substances is obtained through more than one sense, particularly is this true of solids. It does, however, not follow that the various sense organs, capable of being excited or called into action, are of equal significance; one or the other or perhaps several are of prime importance while the others serve merely as adjuvants or remain practically inactive.

In many instances substances will appear similar to one sense while the other senses will disclose marked differences. For example, various salt crystals or solutions may appear similar to the eye, but taste will show that they are widely different. Again, cinchona bark, quinine, quassia wood and colocynth resemble each other as to taste, but

differ widely as to appearance. A solution of salt and hydrogen sulphide resemble each other to the eye, but the important distinguishing character of one is revealed through the sense of taste while that of the other is revealed through the sense of smell. It is therefore evident that the significance of the different senses in the recognition and examination of substances is variable. We must also keep in mind the immediate and remote manifestations of properties. This applies especially to poisonous and other noxious substances taken internally or applied externally. For instance quinine and morphine resemble each other as to taste and general appearance, but the effects they produce upon the system when taken internally are widely different.

Development and training of the senses is of great importance and greatly modifies our knowledge of things. Substances may appear similar to the uneducated but the educated and experienced will note marked differences. The discerning power of the senses may also be greatly enhanced by artificial aids. Two or more substances may appear wholly similar to the naked eye while the microscope will reveal marked differences. The abnormal or pathological condition of the sense organs also greatly modifies our knowledge or information of things. Every one knows that "a cold in the head" or nasal catarrh renders the sense of smell almost inert.

The expression of our knowledge of things is essentially in terms of comparison. A substance is soft, hard, bitter, warm, cold, red, green, etc., in comparison with our knowledge of the properties named as previously experienced from a study of substances possessing these properties qualitatively and quantitatively similar or dissimilar. A substance is like or unlike another substance with which it is compared. This naturally brings up the subject of standards of comparison which shall be discussed more specific-

ally with the special consideration of the senses. It becomes evident that a property which is to serve as a standard of comparison must be constant and its comparative value must be capable of being measured. Since the properties of substances cannot be more constant than the substances themselves it is evidently impossible to find absolutely fixed and unchangeable standards of comparison, since all substances undergo continual change. Nevertheless, some properties are sufficiently constant to serve as very reliable standards, as for example linear measurements as determined by the appropriate standards, the colors of the solar spectrum, specific gravity of certain substances, temperature, etc. On the other hand there are properties which may not be standardized, as odors and some tastes, many tactile sensations, etc. The accuracy of our knowledge of things is proportionate to the constancy of the available standards and our ability to make reliable comparisons.

As already indicated our knowledge of things is modified by the condition of the sense organs. If they are imperfectly developed or in any way abnormal our information regarding things is proportionately incomplete and defective. In other words our information concerning things is delimited by the functional activities of the sense organs. If we were in possession of additional sense organs or if those we possess were more highly developed our knowledge would be proportionately more complete and comprehensive. There is no doubt that the things with which we come in daily contact possess innumerable properties wholly unknown to us simply because we do not have adequate sense organs to acquaint us with them. Nature is full of sounds which escape our notice because the sound waves are too short, too few or too numerous to impress the organ of hearing. Some persons even fail to hear the noise made by the cricket because the notes are too high.

There are doubtless many light waves which the human eye has never seen. There are many odors which have never been smelled and tactile stimuli which have never been felt.

With these preliminary statements we shall now enter into a more detailed consideration of senses and sense organs in their relationship to each other and the special application we may make of them in the study of drugs. We shall also enter into a consideration of those factors which modify drug characters and which are apt to mislead the student in estimating the purity of vegetable drugs, whether in the crude or powdered form.

# GENERAL VEGETABLE PHARMACOGRAPHY.

## CHAPTER I.

### GENERAL DISCUSSION OF THE SENSES.

In order that the student may comprehend the full significance of sense perception in the examination of drugs it is necessary to consider some of the general facts underlying the activities of sense organs. What is the probable origin and relationship of the sense organs? Why have we only five senses and is it probable that the future will develop other senses and perfect those we already possess? How are we enabled to recognize and determine the properties of substances and how do we establish standards of comparison? What valuation may we place upon the information gained through our senses and which of the senses are most important in the examination of drugs and related substances? These are some of the questions which we shall discuss very briefly by way of introduction to the special consideration of the senses in the study of vegetable drugs.

### I. THE PHYSIOLOGICAL BASIS OF SENSATIONS AND KNOWLEDGE.

Sense perceptions are due to stimuli capable of acting upon the sense organs in such a way as to induce functional activity. Each sense organ may only be stimulated functionally by such energies as have induced its phyloge-

netic origin and development as shall be explained more fully in the following chapter. Stimuli which act upon the sense of hearing do not cause sight sensations or taste sensations and the stimuli causing smell are not appreciated as touch sensations. It is evident that the sensation cannot have any subjective existence unless the adequate stimulus exists, and it also follows that the sense organ must exist and must be capable of being stimulated. In other words without the appropriate stimulus the sensation could not be nor could the sensation be induced without a responsive sense organ and a cognizant brain center. It would be entirely impracticable to enter into a discussion of the anatomy and physiology of sense organs. The student is supposed to be familiar with human anatomy and physiology in a general way at least. Some knowledge of experimental psychology involving time measurements of stimuli, responses to stimuli, qualitative and quantitative measurements of stimuli, etc., are really necessary to understand this part of the subject. In lieu of such experimental experience the student is obliged to take the truthfulness of most of the statements on faith. The fact to be fully realized and understood is that sensations are due to stimuli acting upon responsive material sense organs, hence a sensation has a wholly material basis and cannot be considered as something spiritual or independent of organized matter. Since our knowledge of things is based upon information given *via* the sense organs, learning must have a wholly material basis. It is also necessary to keep in mind that our present knowledge of things is the result of the accumulated inherited experiences of the past combined with the experiences of our present existence; that is we cognize according to our inherited mental capacity and experience. If the inherited mental capacity was good we are in possession of good sense organs and hence the capacity to learn

is good. If the opposite conditions exist the individual is said to be dull, slow or stupid.

The material origin and basis of sensations and knowledge is generally recognized and understood by physiologists, although psychologists persist in treating mind as separate from matter. It is undeniable that mind can only appreciate such information as is transmitted *via* the sense organs. The mind is also so constituted that our information of things is accurate and complete according to the number of sense organs acted upon, other things being equal. This fact is fully appreciated and put into practice by modern educators. For example, in teaching a child to read, the sentence is read by the teacher which impresses the idea or thought *via* the organ of hearing; it is written which impresses it upon sight; the ideas expressed by the sentence are even acted out in so far as that is possible which may impress one, several, or all senses, as the case may be.

## II. THE EVOLUTION AND RELATIONSHIP OF THE SENSES.

Since sensations are due to stimuli capable of acting upon the sense organs and hence have a wholly physiological basis, it becomes evident upon consideration that the sense organs are the product of evolution. It is also evident that the evolution of the sense organs is guided and controlled by external stimuli. It would be impracticable to enter into a full discussion of the theoretical and problematical side of the evolution and relationship of the senses and sense organs, but a brief consideration of the subject in the light of known facts will be of great value in gaining a better insight into the functional activities of the sense organs as they now exist.

The tactile sense or the sense of touch is doubtless the

oldest; the one which came into existence first; seeing, smelling, hearing and tasting being simply modifications of this primal or basic sense. It must, however, be kept in mind that the sense of touch as it now exists in man is greatly different from the primitive tactile sense as it existed in the primal organisms of the geologic ages or as it now exists in the lower plants and animals. The very first stimulus to which organisms were exposed was the contact of external objects; this applied especially to organisms endowed with the power of locomotion. The motile power brought them in more frequent contact with various substances, whether they served as food, as protection or some other purpose. In fact the motile power was primarily induced by contact stimuli. A contact stimulus by an external object caused excessive contraction of the protoplasm at the contact area, tending to propel the organism away from the source of the stimulus. The ability to cognize the stimulus, that is, to differentiate between desirable and undesirable objects, was a much later development; in fact is only met with among the higher animals. It is not reasonable to suppose that such organisms as amoeba, desmids, bacteria, diatoms, paramecia, hydra and a host of other low motile organisms have the capacity to cognize objects with which they come in contact. The apparently selective responses to contact stimuli can be traced to chemical and physical differences of the substances concerned. (Protoplasm and contact objects.) As these contact stimuli continued to act and react upon the organism there were produced certain morphological modifications in response to the stimuli; that is the stimuli gave rise to structural modifications indicative of the first development of tactile organs or a tactile sense as distinct from related sense organs. It is evident that these first tactile sensations where of a very general nature; the organisms

simply responded to certain waves of energy, emanating from extraneous substances without obtaining any impression of form, size, color, use, etc. In time the organism acquired the ability to distinguish between contact objects which were useful (as food or for protection) and those which were not, and the primitive general sense organ was accordingly modified structurally. The fact to be kept clearly in mind is that a change in function implies a corresponding change in structure. In this connection it might be mentioned that the attempts by various scientists to prove that function precedes organization or that organization precedes function are futile. Neither assumption is correct; function and organization are interdependent and inseparable. One without the other is wholly impossible. To speak of a function without a corresponding organ or structural adaptation, is simply a misinterpretation of terms, due to a lack of information.

Since sensations are simply the result of force impressions emanating from matter and acting upon matter, it is evident that no sense organs will develop which do not represent some form of energy. Some stimuli are more general or common than others and these give the initiative to sense development. As explained above, the tactile sense was first to develop because contact stimuli are omnipresent. The next most constant stimulus emanates from the sun, stars and other luminous bodies. Since most organisms are exposed to direct or indirect sunlight, and since light is indispensable to continued normal life, it is evident that early adaptations were made to cognize and utilize this beneficent force. Light stimuli resemble contact stimuli in that they are induced by energy vibrations transmitted to the living organism. In both instances the energy emitting substances do not come in actual contact with the organism or the sense organ. When the hand touches a

bar of iron the bar does not come in actual contact with the sensory nerve endings. There is a layer of epidermal cells (dead cells) and a layer of air intervening. This recalls the story of the man who was placed on trial for assault and battery. The defendant boldly declared that he did not bring his fist in forcible contact with his adversary's nose as stated by the prosecution; that he was prevented in doing so by an intervening layer of atmosphere. This was indeed truth but nevertheless the forcibly projected fist compressed the layer of atmosphere sufficiently to act upon the dead epidermal cells which in turn pressed upon the underlying tissues including the sensory nerves, giving rise to the usual sensations resulting from a blow. The fact remains that the objects giving rise to tactile and light stimuli never come in direct contact with the responsive cytoplasmic structure, tissue or organ; even in the lowest organisms. Light stimuli are much more subtle and refined than contact stimuli. Whether the luminous body is near or remote, the light stimuli must be transmitted *via* the hypothetical ether and must act upon an appropriate morphological adaptation of some living portion of the organism. In those primitive organisms having already developed the tactile sense and a dependent motile power a specialized portion or bit of the cytoplasm began to cognize light stimuli. It is highly probable that the ability to respond to contact stimuli prepared the way to the appreciation of light stimuli. The modification of an originally tactile sense became more and more suited to cognize light stimuli until finally it could appreciate these stimuli only. For example, the primitive optic sense organ of *Euglena* (a single celled alga) represented by the red eye-spot, is sensitive to light but it is also exceedingly sensitive to tactile stimuli (photo-tactile sense) while the optic apparatus of higher organisms respond to light stimuli only. The lower

organisms could only recognize light and differences in light intensity without being able to recognize form and color since the visual apparatus is met with among the higher organisms only.

The sense of taste was in all probability the third in the order of development, although it is more closely akin to the tactile sense than the sense of sight. The various substances with which organisms came in contact, especially substances in solution and those which entered into solution with the moisture of the organisms, differed chemically, though they may have been similar in temperature and specific gravity. These chemical differences caused differences in the modality of the contact stimuli. An alkaline solution of a given temperature and specific gravity irritated the tactile sense differently from an acid solution of a given temperature and specific gravity. The ability to respond to these chemical differences constituted the primitive taste sense. In time a portion of the tactile apparatus became specialized to note these chemical differences of solutions and soluble substances and the gustatory apparatus had its origin. The ability to cognize sapid substances did, however, not develop until comparatively late in the history of evolution as we find no distinctive gustatory apparatus among the lower organisms.

The sense of smell is the fourth in the order of evolutional development. Odoriferous substances are in a gaseous state emanating from various solids and liquids with which organisms came in contact. Since these odoriferous principles in a measure indicate the chemical and physical nature of the substances they are also the indicators of the utility of the substances; undesirable objects emitting a disagreeable odor (subjectively considered) and desirable objects an agreeable odor. It is highly probable that the lower organisms (protozoa and protophyta) do not cognize odors.

In the first place most of these organisms are aquatic in their habits and hence are not exposed to gaseous odor stimuli, and since gases are absorbed by liquids they would be appreciated by the taste sense, if at all.

It is highly probable that hearing was the last sense to develop, although among the higher organisms it ranks next to sight in importance and utility. Naturally this sense could only become very useful after organisms (animals) had obtained such high organization as to be able to utter sounds by way of attracting attention or for the purposes of communication. No auditory sense is traceable among plants and among protozoa and the lower metozoa. The sounds of nature, as the wind, the hurricane, thunder, the splashing of waves, the rippling of the brook, etc., could not have much effect; the sound would certainly have less influence than the disturbances causing the sound. It is highly probable that the ability to cognize sound was coincident with the ability to utter sounds. The ability to utter sounds developed after organisms had become highly organized, when the struggle for existence compelled them to unite for protection or aggression. Among the invertebrates the ability to cognize sounds uttered by the higher vertebrates gave an opportunity to hide or escape from the noisy enemy. In such cases the development of the sense organ is due to the noises uttered by the higher organisms rather than the noises made by inanimate objects.

By way of a further statement of the evolution of the senses we shall refer briefly to the sense organs as they occur in various organisms.

The tactile sense no doubt exists in all organisms (plants and animals). Every bit of living protoplasm is endowed with a form of general sensibility. As we study the more highly organized organisms we note a corresponding specialization of the tactile sense. In the sea-anemones the

tentacles are most sensitive; in the snail, the horns; among insects the antennae; in the oyster the edge of the mantle; in fishes the mouth; in snakes the tongue; in birds the beak and lower side of toes; in monkeys and man the tip of the tongue, the lips and the ends of the fingers. There is a relationship between the delicacy of touch and the general intelligence of organisms. Cats and dogs are more sensitive to tactile impressions than cows and horses and are correspondingly more intelligent. The elephant has great intelligence and has a corresponding high tactual sense. The sense of touch is much more delicate in the educated and intelligent than in idiots, the dull and uneducated.

Many plants respond to contact stimuli. The leaves of the *Mimosa* are very sensitive. The glandular hairs of the insectivorous *Drosera* are exceedingly sensitive to tactile stimuli. The winding of tendrils is induced by contact stimuli. The so-called sleep movements are essentially induced by tactile stimuli.

In man the sense of touch is indeed very highly specialized and complicated. The ability to cognize differences of temperature is generally recognized as a tactile sense though it is essentially different in modality. It may be that the temperature sense organ is in progress of development though physiologists have thus far no satisfactory evidence of such an evolution.

The ability to cognize light and differences of light intensity does not imply the power to visualize. Protozoa, protophyta, the lower radiates and mollusks, some worms, are wholly devoid of the power to see objects; they only cognize light and are enabled to utilize it. We find image forming eyes (*ocelli*) at the tips of the tentacles of the snail. The scallop (*Pecten*) has similar eyes in the edge of the mantle. Myriapods, spiders, scorpions and caterpillars also have simple ocelli. Crabs, lobsters and insects have com-

pound eyes consisting of a large number of ocelli. In man and the higher vertebrates there is a complex, image forming and accommodating mechanism. The visual apparatus is highly important in enabling organisms to locate food or other objects of utility as well as to cognize enemies and other undesirable objects. Naturally the eyes are placed near the anterior end of fore and aft organisms as in this position they prove of greatest utility.

While most plants utilize and respond to light stimuli yet in no instance is there any visual organ. The red eye-spot of *Euglena* (protophyta) is merely a plasmic area near the anterior end of this single-celled organism which is sensitive to light. The apparent movements of higher plants and parts of plants with reference to the source of light (negative and positive heliotropism) are due to differences of growth and variations in turgescense. Chlorophyll granules respond to light stimuli very promptly as is indicated by their movements enabling them to utilize the optimum of light intensity. Since the functional activity of chlorophyll depends upon sunlight it is reasonable to suppose that these organic units should show a high adaptation to light stimuli.

The sense of taste is more refined than the sense of touch. It gives knowledge of properties which cannot be felt; though, as we shall learn later, some tactile sensations are designated as tastes. The sense of taste is very important in the selection of food and is therefore placed near the entrance of the digestive tract. As already stated the lower organisms (protozoa, protophyta) do not possess a gustatory apparatus. Many of the movements of protozoa, bacteria, desmids, diatoms, antherozoids, etc., are induced by chemical differences of the liquids and would thus indicate the beginnings of a gustatory sense but there is no experimental evidence that these organisms cognize the stimuli.

In spite of the remote origin of this sense there is no distinctive gustatory organ among the invertebrates. Even in fishes, amphibians, reptiles and birds this sense is very obtuse. In man it is very highly developed.

Many invertebrates have a highly developed sense of smell, as snails, flies, carrion beetles and bees. There is no conclusive evidence that protozoa and protophyta recognize odors. In the higher vertebrates, including man, the olfactory apparatus is placed at the entrance of the respiratory tract and is very highly specialized though quite variable in delicacy. Some animals are very sensitive to odors as carnivorous quadrupeds and some herbivora. In fishes and reptiles it is very feeble. In man it is less delicate than in some lower animals, the dog for example, but it has a wider range than in any other animal. Plants are apparently wholly devoid of the sense of smell.

The lower plants and animals as protophyta and protozoa are incapable of recognizing sounds. The simplest organ of hearing as it exists among certain invertebrates consists of an intercellular sac filled with a fluid in which the auditory nerve floats, associated with certain granules (otoliths). In the clam such a primitive auditory apparatus is found at the base of the foot; in some grasshoppers at the forelegs; in other insects in the wings. Lobsters and crabs have auditory sacs at the base of the antennae. Nearly all vertebrates have a highly developed and complex auditory organ. In some animals this sense is much more delicate than in man, but man is capable of appreciating a wider range and quality of sounds.

We have attempted to show the evolutional relationship of the sense organs and the corresponding senses. We have shown that the sense organs are the product of certain stimuli emanating from substances constituting the environment of living organisms. This being the case it might be

supposed that all possible sense developing stimuli have had an opportunity to act upon living organisms and have therefore developed all the possible sense organs to the highest degree. This is, however, in all probability, far from the truth. As indicated, sense organs are very slow in being created and are very slow in being developed. It is perfectly natural and reasonable to suppose that the sense organs we now possess will become more and more highly perfected and that other sense organs are gradually being created. One may even conjecture what some of the additional sense organs may be, but this must remain mere conjecturing until at least the rudiments of additional sense organs have actual existence. It is believed by many that we are developing a mind reading sense; that is, a sense organ which will enable us to cognize the thoughts of others. While this is not necessarily impossible, but rather highly probable, there is no evidence that such a sense exists, even of the most rudimentary kind. As our senses become more perfect and as we develop new senses, our knowledge of things will become accordingly more perfect and complete.

## III. THE LIMITATION OF KNOWLEDGE.

From the consideration of the evolution and relationship of the senses and sense organs it becomes evident that we may define the limits to learning and knowledge. We may know only that concerning which our senses give information. Our perception of form and color is accurately delimited by the visual sense. We may hear only such sounds as are capable of stimulating the auditory apparatus to functional activity. We may taste only such substances as will stimulate the gustatory nerves. The mind can only grasp such ideas as are based upon previous sense expe-

riences, direct and indirect, inherited and acquired. Our conception of the magnitude of the universe is definitely limited by our visualization of heavenly bodies associated with our conception of distances or interstellar space. Our most grotesque mental imagery is created by and limited by the perceptive faculties of the senses. One may have a mental image of a monster with the head of a lion, the body of a serpent, enormous bat-like wings, enormous webbed feet, etc. If we analyze the mental picture we find that all its parts are built up of preconceived sense impressions. In other words the mind is wholly incapable of forming a mental concept not based upon sense experience. As our sense organs are finite and very limited in their powers, so is our knowledge finite and limited. A sense organ can give only such information as coincides with its functional development.

We shall not enter into a consideration of the relationship of the sense organs to the corresponding brain centers, as the subject requires much study and furthermore there is much which is not fully understood. The newer experimental psychology has done much in this line and it is to be hoped that some of the obscure points may be cleared up more and more.

## IV. KNOWLEDGE BASED UPON COMPARISON.

Learning is largely a matter of self conscious or unconscious comparison. One color is like or unlike another with which we are familiar. A taste is compared with a previous taste, one odor recalls another, or by contrast is recognized as being different. We are continually making comparisons of form, of color, of temperature. As our comparisons are accurate and reliable so is our information accurate and reliable.

In order to make comparisons we must have the power of memory; otherwise the past would be a blank and our entire existence would be merely a series of present sense experiences. The power of comparison is also greatly modified by the power of association. A taste may not only recall another taste of a similar nature, but it will recall the appearance and odor of the substance; it may recall incidents and occurrences, people and places, etc., which may not have any direct connection with the subject under consideration but it gives some indication of the working capacity of the mind.

In order to make reliable comparisons we must adopt reliable standards of comparisons. As we shall learn later it is in many instances a want of suitable standards which makes our knowledge of things and of qualities inaccurate, incomplete and unsatisfactory. The ability to give expression to our mental concepts is also of great importance as by this means we are enabled to convey knowledge to others. In this connection it may be stated that the ability to give expression to our thoughts is proportionate to our knowledge of the thing which we desire to express or explain. That is, in the majority of instances the inability to give a clear explanation is due to insufficient information. The inadequately experienced and ignorant are apt to flounder and to use wrong words or meaningless words in attempting to explain. Those who really have a clear mental concept of the subject have no trouble in making themselves understood either by words or by signs.

It is impracticable to enter into a fuller discussion of mental operations as they apply to learning and knowledge. Those who have the ability and desire are referred to works on mental philosophy, psychology and on pedagogy.

## V. THE SEQUENCE OF SENSE APPLICATION.

As already indicated, we should make use of all our senses in so far as that is possible. We should not only look at the object, but we should touch and possibly taste and smell it. Though all of the senses should be brought into action there must be a logical sequence in which they should be applied. Naturally the optic apparatus is the first to act or to be called into action. In fact most of our knowledge is gained through this sense as in reading. Many substances may be appreciated through this sense only, as for instance the heavenly bodies and other distant objects. The order of the other senses is somewhat variable; hearing may even be first if sounds are uttered, or perhaps it may be the sense of smell. In by far the greater number of cases the sense of touch comes second; that is touch as revealed through hands and fingers. Smelling usually comes next and taste last of all. As indicated the sequence will of necessity vary and must be suitably adapted to the substance under examination. The point to be remembered is to make use of as many of the senses as possible.

In the case of vegetable drugs, whether in the crude or powdered state, the following is the natural sequence. Sight, touch, smell, taste and lastly hearing. There is no occasion to deviate from this sequence. The eye may be unaided or its perception strengthened by glasses, simple lenses and the compound microscope combined with suitable micro-chemical reagents. This sense gives us an idea of the general conformation, size and color of the drug. Touch is brought into requisition next, in fact while inspecting a drug macroscopically we are usually also touching it. Touch gives us an idea of such properties as hardness, flexibility, brittleness, softness, grittiness mucilaginous state, etc. Sight and touch are combined in making measurements. After sight and touch the sense of smell

should be applied rather than taste, as this sequence will guard against hasty and promiscuous tasting of drugs which are poisonous and it also prevents the intermingling of odor and taste, especially of drugs having so-called aromatic tastes. Hearing is practically of no consequence in the examination of drugs.

# CHAPTER II.

## SPECIAL DISCUSSION OF THE SENSES WITH REFERENCE TO THE EXAMINATION OF VEGETABLE DRUGS.

We shall now take up the consideration of the practical application of the senses in the examination of vegetable drugs. We shall not enter into a consideration of the special anatomy and physiology of the sense organs, excepting in instances where brief references are necessary to make the explanations more clear. The discussion of standards of comparison has special reference to their value and significance in the examination of drugs.

The discussion of the senses will be taken up in the order of their more usual sequence in the examination of drugs. It is hoped that the student will be able to modify or adapt the suggestions given to the varying conditions of time and place. Thus applied the suggestions will prove useful in the college course, the state examination and in the occupation as a practicing pharmacist.

### I. LIGHT AND STANDARDS OF COLOR AND FORM.

We shall not enter into the consideration of the anatomy and physiology of the visual organ. The student is referred to any standard work on human physiology. Much might also be said of the proper training and exercising of the eyes as well as defects of vision and their influence upon the visualizing power. These subjects likewise may be studied more in detail in the many special works found upon the market.

The visual apparatus enables us to become cognizant of differences in light intensity, of the form and position of objects, and of color inclusive of variations in color. The subject of the color of drugs as well as of other substances is still confused for several reasons. First, because there are no reliable standards of color, and second, because of the variable naming of colors. The artificial color standards used by teachers of the primary grades, artists, cloth manufacturers, furniture and house painters, etc., are very far from reliable. No matter from what material the color is made or how carefully it is prepared, it is subject to variation in intensity and quality. The most durable colors used by artisans at the present time lose their factory gloss or tint in a very short time. Some of the colors used by ancient mural painters and by Orientals of the present time are more durable, but far from unchangeable. It is practically impossible to print color scales which are uniform throughout and which will not fade. It has been suggested that certain substances having well recognized and comparatively permanent colors be used as standards of comparison, as the chocolate brown of chocolate, the saffron yellow of a standard solution of Spanish saffron, etc. I have found solutions of the so-called Diamond dyes comparatively permanent, more so than the aniline dyes as ordinarily employed by biologists. Even these substances are subject to error in preparation and are not sufficiently permanent to serve as reliable standards. It would be possible to prepare a natural scale of colors by projecting the prismatic colors of direct sunlight upon a uniform screen. It would be necessary to use prisms of uniform size and made of a uniform quality of glass. Any desired tint or shade could be produced by interposing various shades and tints of milk glass and smoked glass of standard thickness. Even such a standard of colors is subject to some variation,

leaving out of consideration personal differences in visualizing power and the power to discriminate between differences in color. Those with defective eye-sight will have difficulty in recognizing many tints and shades. Those who have inherited color blindness (achromatopsy, Daltonism) fail to recognize certain colors entirely.

Perhaps the greatest obstacle to the recognition and comparison of colors is the confused naming of colors or rather the use of terms which can only be understood by those who are familiar with the colors referred to. For instance such names as purple, royal purple, scarlet, indigo, violet, crimson, magenta, ecru, mauve, cerise, heliotrope, lavender, marine blue, terra cotta, Pompeian red, canary red, Chinese yellow, etc., etc., are wholly devoid of meaning to the uninitiated. All the possible colors are simply the recognizable tints and shades of the primary colors red, yellow and blue, and the recognizable admixtures of these primary colors. It would therefore be possible to select such color names as would indicate the shade or tint of any primary color or admixture of primary colors in such a manner as to be comprehended by any one and enable him to reproduce the color if desirable. Such a system of color nomenclature has been proposed by Prang. Prang worked upon this scheme for nearly half a century and it is doubtless the most complete system of its kind. It is extensively used for teaching colors in schools, by artists and by manufacturers of colored fabrics of all kinds.

Prang's color scale is made from artificially prepared colors printed upon paper, and is therefore not a reliable standard. There are a multitude of conditions which modify the colors of the plates. Variations in the mixing of the colors, differences in the quality and thickness of the paper used, differences in the force of the press, etc. Even should the thousands of copies come quite uniform from the press

the colors will subsequently fade and the rate of fading will depend largely upon the amount of handling and exposure to light. In spite of all these objections the colors are fairly reliable as standards of comparison. Prang's color nomenclature is simple and can readily be understood and applied by anyone. It may be applied in giving the colors of the powdered vegetable drugs and we shall here explain the scale and the naming of the colors as proposed by Prang.

The entire scale consists of seven plates, each plate being divided into seven horizontal rows, and each row is again broken into twenty-four rectangles of distinct colors. The top horizontal row of plate I represents the normal colors of the spectrum—namely, the primary colors, red, yellow and blue, with their admixtures named as follows: Those having red in their composition are red, red red orange, red orange, orange, orange yellow orange, yellow orange, yellow yellow orange; next the yellow and its admixtures, with blue as yellow, yellow yellow green, yellow green, green yellow green, green, green blue green, blue green and blue blue green; lastly follows blue, with its admixtures of red, blue blue violet, blue violet, violet blue violet, violet, violet red violet, red violet, red red violet, which completes the color cycle and takes us back to red again. In indicating this nomenclature the author simply uses the initials of the color names, as R, RRO, RO, etc. The vertical row below each color of the first horizontal row represents the tints of the top color. The second plate is an exact reproduction of the first plate, excepting that it has been gone over with a definite amount of black, producing the first shade series, the top horizontal row representing the normal of the first shade series, while the vertical rows represent the tints of the normal shade series. Plate three is like the second, only it rep-

resents the second shade series with its tints; plate four represents the third shade series, etc., plate seven representing the sixth and last shade series with its tints. In all there are 1,176 shades and tints represented. Throughout the author uses an abbreviated reference system. If, for instance, it is desired to indicate the fifth tint of red orange of the third shade series, it is expressed as follows: 3OR5, which means that this particular color is to be found on the fourth plate in that rectangle of the fifth horizontal row indicated by OR at the top of the vertical row in which the rectangle is situated.

It must also be borne in mind that form and texture greatly modify the color. This is true of drugs as well as other substances. The same color on a rough and a smooth surface will present a markedly different tone; the rough surface producing a shade effect, hence the color will appear darker. In the case of powdered drugs it will be noticed that fineness greatly modifies the color, the finer powders producing tint effects as a rule. In some instances a difference in fineness may even modify the quality of the color entirely (licorice root). This difference in form, texture, etc., will frequently cause considerable difficulty in making comparisons. Other conditions modifying the color and form of drugs will be mentioned in Chapter III.

The form of vegetable drugs is much more variable than their color, and it would be entirely impracticable to enter into a consideration of the different form types represented by the different drugs. This part of the subject is to be studied in the different works on botany, especially pharmaceutical botany. As regards the dimensions of drugs, we have absolutely reliable standards of comparison—namely, the metric or English linear measure and the metric or English micrometer scales used in making measurements of

miscroscopic objects. On account of its simplicity the metric system is to be preferred in all instances.

We need scarcely urge the necessity of good illumination in the inspection of drugs. We wish, however, to urge the necessity of thoroughness. Free use should be made of a good pocket lens with wide aperture. The drug should be carefully compared with the description given in the text-book. In nearly every instance the student will find some slight deviations of the characteristics observed and those given in the book. The authors of the various text-books have endeavored to give the characteristics of the type or representative specimens. The specimen studied may vary considerably from the type description. An effort should therefore be made to account for the differences, whether they are differences of form, size, color, odor or taste (Chapter III). Students are apt to be careless in regard to the presence of apparently unimportant, unusual or uncommon structural characters, as, for instance, the prickles on the bark of prickly ash, the presence of hair-cells on leaf-stalks and venation of the leaves of hyoscyamus, lenticular structures on barks, presence of lichens and fungi on stem barks and their absence on root barks, etc.

Whenever possible the student should make careful drawings of the macroscopic as well as microscopic structure of drugs. The value of this cannot be overestimated. In order to make a correct drawing the student is compelled to study the drug carefully; furthermore the act of making the drawing, as well as the drawing itself, will impress the structural characters more firmly upon the mind.

Many of the leaves and herbs used as medicines appear upon the market much compressed, broken, torn, twisted, folded and distorted, as, for instance, belladonna, stramonium, melissa, digitalis and castanea leaves, many of the herbs and flowers, etc. These should be soaked in water

until they become perfectly pliable, and then carefully separated, unrolled or unfolded and laid flat or dissected upon a plate of window glass or some other suitable background in order to make careful examination possible. Flowers should not be excessively wet for examination, and their dissection is aided by the use of tweezers, dissecting needles and a good pocket lens.

A few drugs resemble each other somewhat as to general appearance, rarely also in taste and odor or absence of odor. These drugs should be studied with special care. This applies particularly to similar plant organs from closely related species and varieties, an item of great importance in the consideration of adulterations. The student must also be careful not to confuse drugs because of a similarity of names, as saffron and American or wild saffron; ipecac and American ipecac, etc.

The following is a list of drugs which resemble each other somewhat, though they are in no wise closely related botanically:

I. Roots, Rhizomes and Tubers.

1. Serpentaria, spigelia, caulophyllum, cypripedium.
2. Ipecac, Apocynum cannabinum, A. androsaemifolium.
3. Aconite, armoracia.
4. Convallaria, triticum.
5. Geranium, blood-root, curcuma, heuchera, chamalirium.
6. Sarsaparilla, menispermum.
7. Veratrum viride, V. album, valerian, dracontium.
8. Iris, calamus.
9. Arum, colchicum.
10. Calumba, frasera.

II. Leaves and Herbs.

1. Belladonna, melissa, hyoscyamus, stramonium, tobacco, scutellaria.

2. Castanea, hamamelis, persica.
3. Digitalis, matico.
4. Chimaphila, uva ursi.
5. Coca, gaultheria.
6. Chirata, scoparius.
7. Mentha viridis, mentha piperita, catnep.

III. Barks.

1. Rubus, mezerion.
2. Ulmus, quillaja.
3. Viburnum prunifolium, wild cherry, alnus.
4. Rhamnus purshiana, granatum.
5. Euonymus, cascarilla, canella.

IV. Fruits and Seeds.

1. Foeniculum, petroselinum, carum, cuminum, anisum, conium.
2. Apple seed, quince seed.
3. Castor beans, croton beans.
4. Black pepper, white pepper, pimenta, cubeb.
5. Sweet orange peel, bitter orange peel, lemon peel.

## II. TACTILE SENSATIONS.

Touch, as it applies to the examination of drugs, is a tactile sensation appreciated by the hand and fingers, the tongue and mouth, rarely also the larynx. The touch of fingers and hands conveys to the mind conceptions of form, of texture, of roughness and smoothness, of moisture, dryness, elasticity, mucilaginous condition, hardness, resistance to fracture, etc. In many instances the sense of touch is merely an aid to the sense of sight—that is, touch verifies or assists the visual judgment as to size, form, roughness, texture, etc.

The tactile sense of the fingers may be greatly increased in delicacy by education and practice and by proper care.

The most sensitive parts of the fingers are the tips; this sensitiveness is greatly enhanced by cleanliness of hands and nails. The nails should be carefully and evenly trimmed, but never very short, as that reduces sensitiveness. The clean, trimmed, free portion of the nail duplicates or magnifies the tactile sense by pressing upon the opposing delicate dermis when the finger is brought in contact with an object. Cold reduces sensitiveness very rapidly; washing in warm water restores the normal activity promptly.

An intelligent use of the tactile sense of hands and fingers, combined with the sense of sight, will enable the student to form a fairly reliable estimate of the histological structure of the drug. If the drug is tenaciously fibrous, without fracture, capable of being torn into long shreds with delicate, hair-like filaments projecting from the free surfaces and ends, we know that bast tissue predominates. If the drug is quite hard, with a splintery fracture, it indicates the predominance of wood fibres or tracheids. If the fracture is short, not fibrous or splintery, and the tissue has a gritty or sandy feel to knife or teeth, it indicates the presence of numerous stone cells (sclerenchyma cells, sclerotic cells), and the absence of bast and wood. Coarsely fibrous barks indicate the presence of large, short bast cells, as in cinchona, cinnamon and others. If the moistened drug become slippery to touch, it indicates the presence of mucilage-bearing cells or mucilaginous cell-walls. If the warmth of the hand produces stickiness of the drug, or if it is sticky when masticated, it indicates the presence of resins. If the drug is heavy, exceedingly hard, fracture short, glossy and chonchoidal, it indicates the predominance of a very thick-walled parenchyma, as in many seeds (nux vomica, vegetable ivory). Great hardness and grittiness, associated with a short, opaque, lustreless fracture, indicate the predominance of sclerotic cells, as in nuts, some seeds

and fruits. If the drug is not hard, fracture short but not glossy, it indicates the predominance of the ordinary parenchyma. If the drug is light and spongy in texture, it indicates large and numerous intercellular air spaces, as in iris, gentian, sumbul and others. If the drug is elastic under pressure, reddish brown, somewhat tenacious, without fracture, it indicates cork tissue. If the drug is "mealy" and light in color, it indicates the presence of much starch. The veins and petioles of leaves are fibrous, due largely to vascular tissue, some bast, wood cells and tracheids.

It must also be remembered that moisture greatly modifies the character of drugs. For instance, a drug which appears quite brittle when dry may become somewhat fibrous upon being soaked in water, indicating the presence of some bast or perhaps elongated parenchyma cells (many barks).

Tactile sensations usually designated as tastes and odors will be explained later. We would advise students to depend largely upon the tactile sense of the hand and fingers, though lips, tongue and mouth are more sensitive. Frequent and promiscuous tasting and chewing of drugs is pernicious for several reasons.

In the examination of drugs the student will have constant use for a good, sharp pocket knife. In order to note the arrangement of vascular tissue, wood fibres, medullary rays, ducts, etc., etc., it is necessary to cut the drug transversely and longitudinally, making it possible to inspect the tissues indicated. This knife will also be very useful in separating the cotyledons of seeds, etc. A hammer may prove useful for crushing very hard seeds and other drugs.

In conclusion is given a tabulation of the plant parts commonly used as drugs, with the predominating cell forms, tissues and cell contents. This will prove useful in the macroscopical as well as microscopical examina-

tion of drugs. It must, however not be supposed that all of the tissues and cell contents enumerated under each group will occur in every drug belonging to that group. It is intended to indicate that the tissues and cell contents named may occur in the drug under examination. For instance, a bark may be very fibrous as revealed macroscopically, indicating that bast predominates; a microscopical examination may reveal some sclerenchyma cells and true cork cells, besides the crystals indicated. Another bark may be free from both bast and sclerenchyma, a fact which can only be determined by making a careful microscopical examination; a third bark may reveal bast, but no sclerenchyma, etc. The examination of the drug is not complete until its histology has been thoroughly studied. Nothing will be said of sectioning, mounting, the use of micro-chemical reagents, etc., as that belongs to the province of vegetable histology and micro-technique, with which the student is supposed to be familiar before entering upon the study of vegetable pharmacognosy.

The tissues are named in the order of their more common relative position, proceeding from without inward—that is, from the periphery to or toward the center. This applies more particularly to barks, roots, rhizomes and stems. It must not be supposed that all possible tissues and cell contents are named, nor is it practicable to give a description of the cell forms.

I. Roots (usually complete, sometimes peeled or cut and broken).

1. Cork, usually typical but deficient.
2. Sclerenchyma, more generally wanting.
3. Parenchyma with much starch or none (roots with inulin); acicular crystals (raphides) of calcium oxalate.
4. Vascular tissue; tracheids; wood fibres.

5. Central pith or parenchyma.

II. Rhizomes (sometimes peeled).
1. Epidermis; some cork; leaf scales.
2. Collenchyma and bast, comparatively rare.
3. Parenchyma, usually rich in starch; crystals.
4. Vascular tissue; tracheids; wood fibres.
5. Abundant central parenchyma.

III. Stems (usually complete; leaves and flowers often included).
1. Epidermis, stomata, hair-cells.
2. Collenchyma.
3. Bast.
4. Parenchyma, usually quite empty.
5. Vascular tissue; wood fibres; tracheids.

IV. Woods (usually in billets or raspings).
1. Tracheids with bordered pits (coniferous woods).
2. Wood fibres; medullary rays; porous ducts.

V. Barks (outer bark sometimes removed).
1. Cork, sometimes removed.
2. Cork parenchyma, inclusive of medullary rays, with some starch and crystals (prismatic and aggregate crystals of calcium oxalate, rarely acicular crystals and crystal powder).
3. Sclerenchyma.
4. Bast, surrounded by crystal-bearing parenchyma.

VI. Leaves (see stems).
1. Epidermis (upper and lower), stomata, hair-cells.
2. Palisade tissue, rich in chlorophyll.
3. Spongy tissue with crystals, especially near the air chambers of the stomata.
4. Oil and resin glands.
5. Vascular tissue with bast and tracheids.

VII. Flowers (see stems).
1. Epidermis; hair-cells; pappus; coloring matter.

2. Parenchyma.
3. Pollen.
4. Vascular tissue, quite deficient.

VIII. Fruits and Parts of Fruits (exclusive of seeds).
1. Epidermis, hair-cells, stomata.
2. Sclerenchyma, often wanting.
3. Parenchyma, cells usually empty.
4. Vascular tissue, deficient.

IX. Seeds.
1. Epidermis with various modifications of the cells; hair-cells.
2. Sclerenchyma and various cell-modifications.
3. Parenchyma (endosperm tissue) rich in starch or proteid granules and oil or fat.
4. Vascular tissue, comparatively deficient.

At the close of this book is given a more complete description of the histology of vegetable drugs, which will be found useful in the study of the microscopic structure of crude drugs, as well as powders.

## III. ODOR AND ODOR STANDARDS.

The sense of smell is as yet imperfectly understood. Considerable theoretical discussion has been entered into lately as regards the chemistry of odor sensations. The olfactory apparatus is undoubtedly the least reliable of all the sense organs. There is no standard of odors, nor do we have any means of measuring odors. A number of individuals may smell the same odor, but they have no means of comparing either the quality or the quantity of the odor. This being the case, it naturally follows that there is no reliable odor nomenclature. Odors are variously classified as agreeable or pleasant, indifferent, strong, faint, fragrant aromatic, heavy, acid, pungent, sweet, etc., words which are variable in meaning and application.

An odoriferous substance must be in a gaseous state and must stimulate the special nerves of smell. The odoriferous gas or vapor must enter the anterior nares in a large and continuous current. If the nostrils are held shut, though the passages are filled with the gas, no odor can be detected. Filling the nostrils with liquids holding odoriferous gases in solution will not act upon the olfactory nerves. It is also interesting to note that odors entering the nostrils by way of the posterior nares cannot be smelled.

The olfactory nerves become fatigued very quickly, as is evidenced by the readiness with which one becomes "accustomed" to an odor. Tenants of ill-ventilated rooms, in which the stench is often overpowering, do not detect any bad odor. Those addicted to the use of tobacco are blissfully unconscious of the strong odor which not only permeates the entire clothing, but also the entire system and the atmosphere about them. Consumers of alcoholic drinks are not aware of their alcoholic breath. Those who habitually eat onions and garlic are not conscious of the sulphurous odor which is so annoying to others. Those affected with ozoena or bad breath, due to nasal catarrh, a disordered stomach or bad teeth, do not detect the odor.

The condition of the olfactory organs greatly modifies the appreciation of odors. If the nasal passages are more or less occluded through catarrhal inflammations, pathological growths as polypoids, etc., the sense of smell may be very much reduced or practically zero. Those affected with chronic nasal catarrh have a weak and otherwise abnormal sense of smell. The sense of smell in different persons differs, not only by inheritance, but also by education. Savage races and many of the higher herbivora and carnivora have an exceedingly acute sense of smell for certain odors, while for other odors this sense is quite dull. Civilized man is capable of detecting the largest number of

different odors. He is also capable of educating this sense to a very high degree, as in "wine-tasters," who are capable of detecting differences in aroma which wholly escape the uneducated and inexperienced.

In order that the sense of smell may be fairly delicate, the nasal passages should be quite roomy, the Schneiderian membrane entirely free from inflammation and other abnormal conditions. The membrane should be quite moist with the natural secretion of the mucus cells, rather than comparatively dry. The nasal passages are also well supplied with nerve ending of common sensation, which will explain why many tactile sensations are mistaken for odors, as, for example, the so-called pungent odors. In contradistinction to the other senses, electrical, thermal and mechanical stimuli do not cause sensations of odor.

The intensity of the odor is directly proportional to the concentration and volume of the odoriferous gas and the rate with which it passes through the nostrils. The olfactory apparatus is extremely sensitive when in a perfectly normal state. According to some authorities, the odor of mercaptan is still quite marked when diluted 300,000,000 times, and becomes inappreciable only when diluted 50,000,000,000 times. The odor of chlorphenol is still noticeable when diluted 1,000,000,000 times. Certain drugs and chemicals will modify the sense of smell. Anodynes and soporifics will reduce it in activity, while strychnin and some other substances will increase its activity.

As regards the estimates of the quality of odors, there is even more uncertainty than there is concerning the quantity. In a general way odors are designated as agreeable or pleasant, indifferent and disagreeable, but it becomes evident that such a classification is very unsatisfactory, owing to personal differences. If we go back to some of the lower organisms, we will find that certain odors are agreeable

because they emanate from desirable substances. The carrion beetle undoubtedly finds the odor of decaying animal matter agreeable. Certain insects are attracted to flowers having the odor of carrion. In fact, all substances, though they may give rise to the most disagreeable odors, according to man's judgment, are eagerly sought after by a host of lower organisms. Even such highly organized animals as buzzards, vultures and hyenas are attracted to decaying animal matter. Many insects are, however, attracted by pleasant odors, as is indicated by the odors of entomophilous flowers. All of the higher animals recognize the odor of the skunk as disagreeable, and this serves as a means of self-defense.

In civilized man the judgment of the quality of odors is greatly influenced by temperament and education; those who fancy the odor of musk are said to be cruel and lacking in culture; those who fancy the simple perfumes, as violet and rose, are said to be cultured and refined; those in favor of mixed odors are said to lack stability of character. Even though there may be little or no truth to these statements, the fact remains that the liking for odors varies greatly. There are some remarkable instances of differences of judgment to be noted. One scholar of much experience maintained that the odor of hydrogen sulphide was agreeable. Most physicians find the odor of carbolic acid pleasant, while many others find it decidedly disagreeable. Some pharmacists maintain that dried taraxicum roots are odorless, while others note a very decided disagreeable odor. The farmer, on entering the crowded habitations of a large city, will note disagreeable odors which escape the notice of the inhabitants entirely. On the other hand, the city dweller, on visiting the farm, will note the disagreeable odors about stables and cattle-pens which the farmer ignores or speaks of as being rather agreeable. Every

farmer enjoys the "fresh smell of the soil," which is a faint musty odor of decaying organic particles associated with the cool vapors arising from the damp, upturned earth.

In man the utility of odors is no longer of prime importance. In some instances, however, they no doubt still serve such a purpose. For instance, we are attracted by the odors of most ripening fruits, as apples, oranges and berries, while we find the odor of poisonous plants, as stramonium, belladonna, tobacco, indian hemp, etc., decidedly disagreeable. There are, however, some fruits which have pleasant odors which are nevertheless inedible to man, as, for instance, the quince (raw).

There are certain suggestions which the student will find useful in testing the odors of vegetable drugs. It is always advisable to leave the examination of drugs with marked odors until the last, as the strong odors will not only be confusing in testing weaker odors, but will dull and fatigue the sense of smell very quickly. Furthermore, if the fingers and hand are brought in contact with a very odoriferous substance, it is no easy matter to remove it preparatory to examining another drug. For instance, if garlic is rubbed on the hand, repeated washings will not remove the odor; in fact, it will often be appreciable for several days. The odor of star anise (Illicium) is also very persistent. All medical students know how difficult it is to remove the dissecting-room odor from hands; repeated washings with soap and hot water and dusting with charcoal is necessary.

As soon as a drug has been tested for its odor and taste it should be laid aside. The odor shoud be removed from hands by washing in warm water and then wiping them perfectly dry with a clean towel.

To develop the odor the cells and glandular structures of the drug should be crushed, thus allowing more of the odoriferous principle to escape. This is readily done with

leaves, herbs, flowers, some fruits and seeds. Place a goodly pinch of the substance in the palm of one hand and crush it with the thumb and finger tips of the other hand, closing the palm as much as possible. The crushing should be done briskly and with considerable force, so as to make sure that the tissues are crushed. Now bring the hand near the nose and open the palm somewhat. The warmth and moisture of the hand causes the odoriferous substance to rise and enter the nostrils. The odor is accentuated by sniffing—that is, by a series of sharp but rapid inhalations, causing the air charged with the odor to enter the nostrils in larger volumes. The hands and fingers should not be wet, as excessive moisture absorbs much of the odoriferous gas and thus reduces the intensity of the odor. If one drug has been crushed in one palm, the second should be crushed in the other palm; this will tend to reduce the mixing and confusing of odors in instances where hurried examinations of several drugs are necesasry and when no opportunity presents itself for removing the first odor from palm and fingers.

If the drug cannot be crushed as indicated, recourse may be had to the pocket-knife. Scrape or cut away some of the drug, place this in the palm of the hand and rub briskly as before. Hard seeds, etc., may be crushed with a hammer and then rubbed in the palm. In some instances simply scraping the surface of the drug will be sufficient to develop a pronounced odor, especially if the surface is very slightly moistened. Occasionally considerable moisture is necessary to develop a decided odor, as in the case of narcotic drugs.

Since there are neither qualitative nor quantitative odor standards, it is difficult to make comparisons, and the information gained from the comparisons is unreliable. Many of the vegetable drugs, however, have very decided odors,

so that it is possible to identify them by this characteristic alone. If we make a comparison of the different drugs we find that those having odors may be grouped according to a similarity of odors as compared with certain types. This grouping would be an easy matter if the odors were simple, but, unfortunately, they are not; most odoriferous drugs have a mixed odor. For instance, chenopodium has a rather faint camphoraceous odor, but in addition it has a very disagreeable odor. Spearmint has a fragrant odor in addition to the aromatic minty odor. Roman pellitory has a faintly aromatic odor in addition to a disagreeable odor resembling that of taraxicum. The odor of calamus is spicy and camphoraceous, etc. Since there is no odor standard, there is also no satisfactory odor nomenclature. Authors speak of sour odor, sweet odor and pungent odor, terms which are wholly meaningless and inapplicable. The so-called sour odor is an odor which we have learned to associate with a sour taste; the sweet odor is so called because of an odor associated with a sweet taste. Some speak of fragrant odors as sweet, which is simply a misuse of the term sweet. As already indicated, pungent odors are tactile sensations.

The following is a classification of the odors to be detected in the more common vegetable drugs. Certain drugs are chosen as types or provisional standards, because they possess the odors in a marked and comparatively pure degree.

## ODORS OF VEGETABLE DRUGS.

A. Agreeable Odors.
  I. Aromatic or Spicy.
    1. Anise Type (spicy and fragrant)—Anise, fennal, star anise, sassafras bark.

2. Chocolate or Cacao Bean Type (faintly aromatic)—Cacao beans, butter and hulls, quarana (faint), coffee (very faint).
3. Cinnamon Type (very spicy or aromatic, related to clove type)—Cinnamons, canella, cinnamodendron, cascarilla, coto-bark.
4. Clove Type (very aromatic)—Cloves, asarum, ginger, pimenta, cubeb, calamus, pepper (not marked), cardamom, coriander, carum, myrica leaves.
5. Foenugreek Type (faintly aromatic, somewhat fragrant, characteristic)—Foenugreek, iris vers., elm bark.
6. Mint Type (very aromatic)—Peppermint, spearmint (aromatic and fragrant), horsemint, pennyroyal, buchu.
7. Nutmeg Type (very aromatic)—Nutmeg, mace, cola nut (faint).

II. Fragrant, Frequently Designated as Sweet.

1. Honey Type (faintly fragrant, related to flower type)—Honey, manna, myrrh, benzoin, storax, quaiacum (very faint).
2. Fruit or Apple Type (very fragrant, related to flower type)—Figs, apples, raisins, prunes, purging cassia, many so-called berries as strawberry, raspberry, etc.
3. Lemon Peel Type (fragrant and aromatic)—Bitter orange peel, sweet orange peel, citron peel, lemon peel, melissa when fresh.
4. Matricaria or Chamomille Type (fragrant, related to tea type, characteristic)—Matricaria, chamomille, brayera, anthemis, matico, lavendula, achillea.

5. Orange Blossom, Rose or Flower Type (very fragrant, related to honey type)—Orange blossoms, apple blossoms, rose, iris flor. (very faint), haematoxylon (faint), sambucus flowers, senna, scutellaria, marrubium, vanilla, spigelia, castanea, carthamus, benzoin (Siam), storax (faint).
6. Wintergreen Type (very fragrant, related to flower type)—Gaultheria, birch, marrubium.
7. Tea or Hay Type (somewhat fragrant, characteristic)—Tea, hamamelis, eupatorium, lavendula, matico, senna, brayera, eriodictyon, erythroxylon, matico, pilocarpus and other leaves; pyrethrum flowers, pulsatilla, uva ursi.
8. Chicory Type (fragrant and somewhat aromatic)—Roasted chicory, phytolacca fruit.

B. Indifferent Odors.

1. Bitter Almond Type (aromatic, somewhat pleasant)—Bitter almond, wild cherry bark, apple seeds, quince seeds and other seeds containing hydrocyanic acid.
2. Caraway Type (aromatic, pleasant to many)—Caraway, coriander, fennel.
3. Camphor Type (characteristic, usually considered disagreeable, terebinthine odor)—Calamus, chenopodium, camphor, grindelia, eucalyptus, juniperus, rosemary, sabina, salvia, santonica, serpentaria, tanacetum, thuja.
4. Bean Type (bland, not pleasant)—Castor beans and croton beans when fresh, calabar beans, beans.
5. Seaweed Type (briny odor, not agreeable)—Characteristic of all seaweeds, as Irish moss.

6. Soil Type (faintly musty odor)—Very marked in sarsaparilla, noticeable in nearly all roots, rhizomes, tubers and most barks, especially when moist.
7. Sumbul Type (musk-like, heavy, disagreeable to many)—Sumbul, santalum album (faint).
8. Jalapa Type (smoky, due to smoke in drying) —Jalapa and other drugs dried over a flame and over open fireplaces, as Russian rhubarb.
9. Tannin Type (a faint odor resembling the jalapa type, noticeable in substances rich in tannin)—Podophyllum, rheum, rumex, rhatany, galla, lappa, chirata, hydrastis, frasera.

C. Disagreeable Odors.

1. Cannabis Indica Type (variously designated as heavy, nauseous, stupefying and suffocating; increased by moisture)—Absinthium, apocynum, asclepias, aspidium (when old), belladonna leaves, calendula, chelidonium, cimicifuga when moist, cypripedium, digitalis leaves, dulcamara, ergot (when old), gelsemium, hellebore, hyoscyamus, Indian hemp, American hemp, ipecac, lactucarium, lobelia, opium, sabadilla, scoparius, senega (when old), stillingia, stramonium leaves and seeds, strophantus, tobacco.
2. Fishberry Type (rancid, due to the decomposition of fats and oils)—Castor beans and croton beans (when old), cocculus Indicus, delphinium, staphisagria, ergot and senega (when old).
3. Garlic or Alliaceous Type (sulphurous odor)—Asafoetida, garlic, onions, galbanum, mustard (when moist).

4. Conium Type (mouse odor)—Conium when moistened with potassium hydrate or other alkaline solution.
5. Melissa Type (ant odor)—Dried melissa, when briskly crushed.
6. Valerian Type (very characteristic, develops with age)—Valerian, Viburnum prunifolium, lupulin, humulus.
7. Taraxicum Type (cow odor, characteristic)—Calumba, phytolacca root, taraxicum, pyrethrum root, inula, althaea, aconite, sympethum, bryonia.

The following is an alphabetical list of drugs which are practically odorless. Few substances are entirely odorless, but in the drugs enumerated the odors are not sufficiently marked to be diagnostic, especially since we have no means of comparing or measuring them. It will also be noted that there are many more drugs which are practically odorless than those which are tasteless, due to the fact that taste-sensations are more readily detected and compared.

## ODORLESS OR NEARLY ODORLESS DRUGS.

1. Areca (odor faintly fragrant).
2. Aconite root (faintly horseradish-like when fresh or moistened).
3. Aspidosperma (faintly aromatic).
4. Belladonna root.
5. Berberis.
6. Bryonia (resembling taraxicum).
7. Calumba (resembling taraxicum).
8. Carbo animalis.
9. Carbo vegetabilis.
10. Caulophyllum.

11. Cetraria.
12. Chamalirium.
13. Chimaphila.
14. Chirata.
15. Cichorium (not roasted).
16. Cinchona (faintly aromatic).
17. Colchicum (seed and corm).
18. Colocynth.
19. Canvallaria.
20. Cornus.
21. Dextrin.
22. Frangula.
23. Geranium.
24. Glycyrrhiza (faint peculiar odor).
25. Gossypium.
26. Granatum bark.
27. Hydrangea (resembling taraxicum).
28. Hyoscyamus seeds.
29. Ignatia beans.
30. Kamala.
31. Leptandra.
32. Linum.
33. Lycopodium.
34. Magnolia.
35. Menispernium.
36. Mezerion.
37. Nux vomica.
38. Pareira.
39. Physostigma (bean-like).
40. Phytolacca root (like taraxicum).
41. Populus.
42. Prinos.
43. Quassia.
44. Quercus.

45. Quillaja (produces sneezing).
46. Rhamnus purshiana.
47. Rhus glabra fruit.
48. Rhus toxicodendron.
49. Rubus.
50. Salix.
51. Sanguinaria.
52. Santalum rubrum.
53. Sarsaparilla (soil odor, marked).
54. Sassafras pith.
55. Scilla.
56. Sinapis (when dry; alliaceous when moist).
57. Triticum repens.
58. Veratrum viride.
59. Viburnum opulus.
60. Xanthoxylum.

Upon careful consideration the student will find that many odors are very difficult of classification. The separation into aromatic and fragrant will depend largely upon judgment; likewise the separation into agreeable, indifferent and disagreeable. The taraxicum type is not recognized by several authors—that is, the drugs under that type are given as odorless, which certainly is not the case, as a careful test will prove. It must, however, be remembered that there are a great variety of factors which will modify the odor of drugs, as has already been indicated, and as will be explained more fully in subsequent chapters.

It should be remembered that the odor of the whole drug may differ qualitatively as well as quantitatively from that of the crushed or bruised drug. The whole drug may have a very decided characteristic odor, which is very much masked or obscured, due to other odors liberated by the crushing process. For example, well-dried, uncrushed or only slightly bruised melissa has a fragrant, lemon-like

odor; when thoroughly crushed, the fragrancy is almost entirely obscured by a very decided disagreeable ant odor. Uncrushed *Mentha viridis* has a very fragrant odor resembling that of the leaves of garden sweet mary; upon crushing there is developed an odor resembling catmint. Crude sabina has the terebinthine odor characteristic of conifers; upon thoroughly crushing there is liberated a peculiar and very disagreeable odor. The same is true of worm seed (santonica) and some other drugs. In consideration of these facts it is advisable to test the odor of the drug before it is crushed as well as afterward.

Since the olfactory apparatus is easily fatigued, it is not advisable to test the odor of many drugs in rapid succession. Thoroughly testing from four to eight drugs in the course of one hour will be sufficient. The intervals should be long enough to enable the olfactory nerves to recover entirely from each stimulus.

## IV. TASTE AND STANDARDS OF TASTE.

A substance to be tasted must be in solution and must come in contact with the gustatory nerve endings. We are capable of recognizing four basic and distinctive tastes, namely—sweet, acid, salt and bitter. The nerve endings which give rise to these different tastes differ structurally and occupy different positions in tongue and oral cavity. Bitter substances produce the most marked effect when placed on the back of the tongue; sweet substances when placed at the tip of the tongue; acids when placed at the lateral edges of the tongue. Any part of the tongue will, however, appreciate any sapid substance. The intensity of the taste is proportional to the strength of the solution and to the gustatory surface acted upon. The sensation requires some time to develop and endures as long as any of the

sapid substance remains. Various stimuli will cause sensations of taste, as electrical currents and contact stimuli.

Temperature greatly modifies this sense. Very hot or very cold substances cannot be tasted; a temperature of about 40 degrees C. is the most favorable. Pungent substances, as pepper, alcohol, etc., greatly obscure any gustatory sensations which may be present at the time.

The gustatory nerves are not readily fatigued, nor is their sensitiveness readily impaired or obscured. It is difficult to cover one taste by another, as is well known by those who are in search for vehicles or menstrua for disguising the taste of disagreeable medicines. Quinine is persistently bitter, no matter what is added to it. Salt is appreciated as long and as often as it may be applied to the tongue. Applying salt and sugar at the same time, both tastes are recognized. A very decided taste may, however, entirely obscure another faint taste.

There are a number of marked and distinctive sensations usually recognized and designated as tastes which are purely tactile sensations and are not due to the stimulation of the gustatory nerves. The most important of these are the so-called pungent, hot or burning tastes of the spices; the astringent taste of tannin-bearing drugs. Some authors also speak of mucilaginous, gritty, sandy and cooling tastes. All of these are merely tactile sensations of the tongue and mouth. Pepper, cinnamon, allspice, alcohol, garlic, onions, horseradish are tasteless as far as the pungency is concerned.

Aromatic taste is also a misnomer. By this term is meant an odor associated with a taste or tactile sensation. For instance, in eating an apple we appreciate a sweet taste, an acid taste and an odor. In the case of cinnamon there is a pungent tactile sensation, a sweetish taste and an aromatic odor. In the case of wine and many other alcoholic

drinks there is a pungent tactile sensation, a sweet taste, an acid taste and an odor. It is evident, therefore, that aromatic tastes may be divided into true aromatic, having a true taste combined with an odor; pseudo-aromatic, having a tactile sensation usually recognized as a taste, combined with an odor; and mixed aromatic, having a tactile sensation and a taste combined with an odor. It is generally understood that the odors associated with aromatic tastes are pleasant. Such terms as aroma, flavor and bouquet are employed in speaking of the aromatic tastes of wines and other drinks, soups, perfumes, etc. Many of the finer aromas of wines, brandy, whisky and other substances are little understood; they are doubtless due to subtle fermentative and chemical changes.

As already indicated, tastes do not develop promptly. In the case of some drugs considerable time elapses before the sensation is well developed. In a few instances the student will conclude that the drug is tasteless, but after a time a taste or tactile sensation will develop, which becomes more and more pronounced, as, for example, the pungency of croton seed. This is doubtless due to the slow solubility of the sapid or pungent substance. In some drugs the taste is obscured by a benumbing effect, as in aconite.

In testing the taste of drugs it is advised not to use more material than is necessary. Since the exposed surfaces of the drugs may be covered with dirt (roots, rhizomes, tubers), dust (barks, fruits, etc.), and other matter which is not only undesirable to be placed in the mouth, but which may mask or otherwise modify the sense of taste, never bite off and masticate bits promiscuously. Proceed as follows: By means of a pocket-knife scrape or cut away the surface layers of the drug and cut out a small bit (about one grain or less), place it in the mouth, pulverize it finely between the front teeth and bring the tongue in contact with the thor-

oughly comminuted and moistened particles, but avoid swallowing any of the particles, and do not allow much of the saliva to pass down the oesophagus. This precaution against large doses and swallowing will serve as a safeguard against annoying or even dangerous if not fatal symptoms from an overdose of very powerful drugs, as aconite, hyoscyamus, belladonna, strophantus and others. The promiscuous chewing and swallowing of drugs, though they are comparatively harmless, will often develop annoying dyspeptic symptoms. It should also be remembered that some individuals are very sensitive to the effects of certain drugs. Minute doses of nutmeg, mace and aconite have been known to produce alarming nervous symptoms.

If the drug is comparatively harmless, there should be no hesitancy about chewing a larger quantity if necessary to develop a decided taste sensation. The student will find that one grain is an average dose of the powerful drugs, as aconite, belladonna, digitalis, hyoscyamus, nux vomica, tobacco, strophantus and others; if this is kept in mind there need be no danger of an overdose, especially if little or none of it is swallowed.

As soon as the taste is fully developed the mouth should be well rinsed with pure water in order to remove the taste preparatory to testing the next. Some taste sensations (bitter), tactile sensations (pungency) and benumbing effects are quite persistent and not easily removed; but several rinsings with lukewarm water will usually be sufficient.

While testing a drug the student should also note concomitant effects, as coloration of saliva, frothiness of saliva, benumbing effects upon tongue and pharynx, mucilaginous condition, grittiness, etc. The student should make the most use possible of tongue, teeth and lips when occasion demands the use of the mouth in the study of drugs.

The following classification of true tastes, so-called aro-

matic tastes and tactile sensations which are generally or occasionally designated as taste sensations will serve as a review of the subject. Familiar examples are chosen for illustration, examples with which every one is more or less familiar:

## TASTES OF VEGETABLE DRUGS.

A. Pure Taste Sensations.
  I. Pleasant or agreeable.
    1. Sweet (pleasant in all degrees of concentration) —Sugar.
    2. Salty saline (agreeable in weak solutions; disagreeable in strong solutions)—Salt.
    3. Acid acidulous, sour; (agreeable in weak solutions; disagreeable in strong solutions)—Vinegar.
  II. Disagreeable.
    1. Bitter (disagreeable in all degrees of solution) —Quinine.

B. Aromatic Taste Sensations (associations of true tastes and tactile sensations with pleasant odors).

I. True Aromatic Sensations (a true taste sensation, usually acid or sweet, associated with an agreeable odor)—Many fruits, candies.

II. Pseudo-Aromatic Sensations (tactile sensation associated with an agreeable odor)—Cloves.

III. Mixed Aromatic Sensations (true taste sensations and tactile sensations associated with agreeable odors)—Some fruits, cinnamon.

C. Tactile Sensations Designated as Taste Sensations.

I. Pungent, Acrid, Hot, Sharp, Biting, Burning (quite generally designated as taste sensations; found with many drugs and all of the spices)—Pepper.

II. Astringent "Puckery" (usually designated as tastes,

and found in many drugs, usually due to tannin; often associated with a bitter or acrid taste)—Alum, green persimmons.

III. Mucilaginous (quite generally designated as a taste sensation)—Slippery elm bark.

IV. Cooling, Refreshing (more generally spoken of as "sensations"; often associated with acid tastes and pungently aromatic drugs, as the mints)—Cool aerated water.

V. Sticky, Gummy—Quite generally designated as "feels." Due to the presence of gums, resins and wax.

VI. Sandy, Gritty—Generally designated as feels. Due to the presence of sand particles, stone cells (the rind of the pear) and other minute hard particles.

Some taste sensations are not primarily due to sapid substances occurring in the drug. For example, the slightly sweet taste of drugs and other substances rich in starch is due to the action of ptyalin, the ferment of saliva, which has the power of converting starch into sugar. As with odor, it is not advisable to taste many drugs in rapid succession; not that the gustatory nerves are easily fatigued, but because one taste sensation should be entirely removed before the second drug is tasted. The so-called pungent tastes are especially difficult to get rid of, as, for instance, those of croton seeds and of mezerium. Some sapid substances require time to enter into solution; hence in hasty work two or three drugs might be tested as to taste before the sensation of the first drug has had time to develop. With some persons reflex dyspeptic symptoms develop after tasting five or six drugs in comparatively rapid succession. More or less painful irritation of lips, mouth and tongue may also follow from the repeated tasting of drugs.

The following is a grouping of the more common vegetable drugs according to taste. The student must keep clearly in mind that the taste of drugs varies quantitatively

and qualitatively with the change in the chemical constituency of the sapid substances.

In this classification astringency and pungency are treated as taste sensations, though, as already stated, they are tactile sensations. Odors should be kept distinct from tastes; hence aromatic tastes is a misnomer which should be avoided. Mucilaginous state, grittiness, cooling sensations, etc., must be considered as pure tactile sensations. Many of the mixed tastes cannot be definitely described.

The following is a tabulation of the simple tastes (inclusive of astringency and pungency) and mixed tastes as they occur in the more common dried vegetable drugs:

## I. Simple Tastes.

1. Sweet.
2. Saline.
3. Acid.
4. Bitter.
5. Astringent.
6. Pungent.

## II. Mixed Tastes.

1. Sweet-acid.
2. Sweet-bitter.
3. Sweet-acid-pungent.
4. Sweet-bitter-pungent.
5. Sweet-pungent-astringent.
6. Sweet-bitter-astringent.
7. Sweet-bitter-astringent-pungent.
8. Sweet-pungent.
9. Saline-bitter.
10. Bitter-pungent.
11. Bitter-astringent.
12. Bitter-pungent-astringent.
13. Pungent-astringent.

## DRUGS WITH SIMPLE TASTES.

I. Sweet*—Althaea, cassia fistula (pulp), cereal coffee, dextrin, taraxicum (very faint), triticum repens, starches.

II. Saline—Chondrus crispus. A pure saline taste is rare. Even in chondrus the saline taste is associated with a bitter taste. Many leaves and flowers have a more or less decided saline taste.

III. Acid—Rhus glabra, vanilla.

IV. Bitter—Absinthium, augustura, anthemis, apocynum, aspidosperma, aurantium flor. (slightly pungent), herberis, bryonia, carthamus (saliva yellow), cetraria (?), chamalirium, chirata, cichorium, cocculus, colocynth, conium, crocus (saliva yellow), digitalis, erythroxylon, gelsemium, hydrastis, ignatia, lactuca, lavendula, lupulin, matricaria, marrubium (also saline), menispernum, nux vomica, pareira, populus, quassia, rhamnus purshiana, scoparius, staphisagria, stramonium leaves and seeds, strophantus, sumbul, thuja, valerian.

V. Astringent—Areca, castanea, galla, gaultheria, geranium, krameria, santalum rubrum.

VI. Pungent—Cantharides (animal drug), capsicum, cardamom, caryophyllus, coriander, coto bark (somewhat bitter), croton seeds, cubeba, hedeoma, lobelia, mace, mentha, methysticum, mezerion, myrica, pimenta, piper, sinapis, zingiber.

## DRUGS WITH MIXED TASTES.

I. Sweet-Acid—Vanilla (?).

II. Sweet-Bitter—Amygdala, dulcamara, frasera, frangula, gentian, lappa, scutellaria, spigelia, taraxicum (?).

III. Sweet-Acid-Pungent—Illicium.

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*Substances rich in starch have a sweetish taste, due to the action of ptyalin, which converts starch into sugar.

IV. Sweet-Bitter-Pungent—Belladonna root, caulophyllum, colchicum corm, convallaria, cypripedium, euonymus, juniper berries, hellebore, podophyllum.

V. Sweet-Bitter-Astringent—Chicorium (roasted), Rosa centifolia.

VI. Sweet-Bitter-Pungent-Astringent—Aspidium.

VII. Sweet-Pungent—Aconite, anisum, carum, cinnamon, foeniculum, glycyrrhiza, hydrangea, jalapa, phytolacca fruit and root, senega.

VIII. Sweet-Pungent-Astringent—Cinnamon (Saigon), sassafras bark.

IX. Saline-Bitter—Marrubium and some other leaves and flowers.

IX. Bitter-Pungent—Arnica, asarum, asclepias, aurantium flowers and peel, belladonna leaves, brayera, calamus, canella, cascarilla, chenopodium, colchicum seed, coto bark, curcumea, delphinium, eucalyptus, grindelia, hyoscyamus leaves and seeds, iris flor., juglans, leptandra, matico, pilocarpus, piscidia, pyrethrum flowers and root, rhamnus cath. seed, rosemary, sabadilla, sanguinaria, santonica, scilla, serpentaria, stillingia, tobacco, tanacetum, veratrum viride, xanthoxylum.

XI. Bitter-Pungent-Astringent — Eucalyptus, myrica, myristica, tanacetum.

XII. Bitter-Astringent—Caffea, chimaphila, cinchona, cornus, eupatorium, granatum bark, guarana, humulus, melissa, prinos, prunus, virg., quercus, rheum, rubus, rumex, salix, thea, theobroma, viburnum op. and prun.

XIII. Pungent-Astringent—Gossypium, quillaja, rhus toxicodendron.

The following drugs are practically tasteless when thoroughly dried:

1. Carbo animalis (entirely tasteless).
2. Carbo veg. (entirely tasteless).

3. Cetraria (slightly bitter).
4. Cydonium (sweetish and very mucilaginous).
5. Erythroxylon (somewhat pungent and benumbing).
6. Guaiacum (somewhat pungent).
7. Kamala (entirely tasteless).
8. Linum (bitterish and mucilaginous).
9. Lycopodium (entirely tasteless).
10. Physostigma (entirely tasteless).
11. Santalum rub. (entirely tasteless).
12. Sassafras pith (mucilaginous).
13. Taraxicum (practically tasteless when old).

## V. HEARING.

The sense of hearing is of no practical value in the examination of drugs. There is more or less snapping and crackling accompanying the fracture of dry, splintery drugs, but the noise made is of no special significance, and can add little or nothing to the information gained through the other senses.

# CHAPTER III.

## CAUSES MODIFYING THE CHARACTERISTICS OF DRUGS.

The student as well as the practicing pharmacist will soon learn that the different drug samples which come under his observation vary greatly as to the gross characteristics. In many instances the deviations from the normal or type specimen are so great that the identity of the drug is not readily recognized. It is, therefore, of prime importance to be cognizant of the possible variations in the gross characters which a drug may undergo before it comes into the hands of the student or pharmacist. It is necessary to enter into a consideration of those factors or influences which are capable of modifying vegetable drugs, as time and manner of collecting, curing, packing, shipping and storing; the influences of climatic conditions, of cultivation, the presence of parasites, etc. If these factors are kept in mind, the student will have little difficulty in determining whether or not a given drug is of fair quality.

It must also be kept in mind that a familiarity with the normal drug is necessary in order to appreciate the deviations from the normal. A thorough knowledge of the normal histology of a drug is necessary to recognize the presence of attacking hyphal fungi, adulterants of powdered drugs, etc.

### I. NORMAL VARIATIONS.

By normal variation is meant such differences in the characteristics of different samples or specimens of the same vegetable drug as are the result of normal, necessary

or unavoidable influences due to time, place and environment. The most notable differences are those of size and form. The main root is larger than its branches, the branches of root and stem again vary in size and form. Leaves in particular, differ greatly in size and form; basal leaves are usually much larger and often of entirely different form from those nearer the top of the plant. Leaves of earlier growth often differ entirely from those of later growth (digitalis, eucalyptus). Some leaves and leaflets are quite uniform in size and form, as those of senna, pilocarpus, coca, gaultheria, uva ursi, etc.

There is also considerable variation in the color of different specimens. Younger parts are likely to assume a darker color and to shrink more upon drying. There are unavoidable variations in the manner of curing, packing and storing which will cause slight differences in the color and other characteristics of the drug. It would be an endless task to enumerate all of the possible normal variations in form, size, color, odor and taste. We can only call the student's attention to their existence and urge upon him the necessity of a careful study of the drug in order that he may distinguish these slight normal variations from those of a more serious nature to be mentioned later. It must not be concluded that every slight variation from the type description given in the text-book indicates an abnormality, a poor quality or an adulteration of the drug.

The student must also keep in mind the manner in which the drug is prepared for the market. Some roots and rhizomes, as sarsaparilla, curcuma, jalapa, are exposed to high temperatures which converts some of the starch into paste and causes the drug to become glossy, brittle and darker in color. The smoky odor of jalapa is due to the fact that the tubers are dried over an open fire. Some rhizomes, roots and barks are partially or wholly peeled. The larger roots

and rhizomes are broken or cut, some longitudinally (belladonna, gentian), some transversely (calumba, inula, dulcamara), some in all possible directions. The student must keep in mind deviations from the customary methods of peeling, cutting and drying. Some drugs are cut by machine, some by hand.

## II. PARASITES.

One of the troubles of the practicing pharmacist is caused by the various vegetable and animal pests which infest vegetable drugs. Some of these parasites attack drug plants before the drug is collected, but the majority of them work their destructive influences after the drug has been dried. Their presence greatly modifies the appearance and value of drugs; it is therefore of great importance to be able to recognize the parasites or the effects they produce. Suggestions on the methods employed to destroy them or to prevent their occurrence will be valuable.

Strictly speaking "parasites" is a misnomer, since the pests referred to attack dead tissues and are hence saprophytic in their habits instead of parasitic, but since they are quite universally designated as parasites we shall retain that term in its older though inaccurate application.

### I. VEGETABLE PARASITES.

The vegetable parasites which are found in and upon the various vegetable drugs belong to the lower forms of plant life as bacteria, hyphal fungi and lichens. Some are present before the drug is collected, as the lichens, less rarely also the hyphal fungi. All external plant parts or tissues are exposed to the presence of a multitude of lower organisms, both plant and animal, and many of these are normally present. For instance a close microscopical examination of the outer layers of barks, the epidermis of flowers, leaves, roots

and rhizomes will reveal the presence of bacteria, insect remnants, low forms of algae, besides other foreign substances which are carried to the plants by air and water currents and are therefore normally and unavoidably present and not an indication of a poor quality or an adulteration of the drug.

### *a. Bacteria.*

Bacteria are practically omnipresent. Owing to their minuteness they are transported from place to place by the slightest air currents. They are circulated in the soil by the currents caused by rains and the evaporation of moisture. They cling to all exposed plant parts. In spite of their omnipresence they probably do not develop in or upon dry drugs in sufficient numbers to produce any material change.

Bacteria are normally present in large numbers in some vegetable substances as the seeds of *Abrus precatorius,* the leaves of *Drosera* and *Nepenthus* and the root tubercles of leguminous plants. They are abnormally present in many drugs. For instance gum opium is mixed with bacteria of the air, from the often dirty hands and instruments of the collectors. It is true many if not all of these bacteria are harmless or are dead, but some may still be viable and harmful (pathogenic), hence caution is advised in tasting some drugs. Some drug-yielding plants are grown in typhoid and malarial districts and the imperfectly cleaned roots and rhizomes may thus serve as disseminators of disease. Though this may happen only very rarely, yet it is worthy of consideration especially in handling and examining comparatively fresh drugs. Barks collected in the vicinity of thickly populated areas are apt to bear some disease germs.

In conclusion we would call attention to the fact that some very important fermentative changes which take

place in drugs during the various stages of curing, are in all probability induced by bacteria. German investigators have shown that the flavor of tobacco is dependent upon the species of bacterium which causes the fermentative changes during the "sweating process." Future investigations may go to prove that the deterioration of stored drugs is due to the presence of bacteria which initiate the destructive chemical changes of alkaloids and other active constituents.

Bacteria frequently cause disease and decay of fresh vegetable substances as for instance pear blight, apple blight, carnation blight, rotting of fleshy fruits, of tubers, bulbs and fleshy roots; but since only few drugs are used in the fresh state these destructive bacteria concern the pharmacist but little.

### *b. Hyphal Fungi.*

Hyphal fungi are higher in the scale of evolution than bacteria and are designated hyphal because, no matter how highly organized they may be, they consist of a more or less densely interwoven network of usually branching elongated (filamentous) cells known as hyphae. There are a great many species, differing widely as to gross characteristics. The student is supposed to be familiar with their general morphology and physiology.

A few drugs are derived from this group of plants of which by far the most important are *Clavipes purpurea* (ergot) and *Ustilago Maydis* (corn smut). Ergot is a fungus which attacks the undeveloped ovaries of rye, wheat and other cereals, causing an abnormal growth of the ovary. Corn smut attacks the developing ovaries of Indian corn. *Polyporus fomentarius* (Zunder, Feuerschwamm) was formerly employed for checking hemorrhage. Impregnated with a solution of salpeter it is still extensively employed in

certain localities for lighting fires, aided by flint and steel. *Lycoperdon giganteum* (Surgeon's fungus) is still a popular remedy in certain countries for checking hemorrhage.

In looking over a collection of leaves and herbs there will be some leaves and herbaceous stems with circumscribed areas of a dark or brown color indicating the presence of a blight fungus which attacked the plant before the drug was collected. A careful inspection of the unpeeled tree barks may reveal the presence of black spots about the size of a pin-head; these are the apothecia of spot fungi, or perhaps lichens, to be mentioned later. Since these spot fungi do not occur upon root barks their absence or presence is of some diagnostic value. Since parasitic fungi are so widely distributed, one may expect to find them normally present in many drugs. The drug, however, decreases in value with the increase in the areas infected. The fungi destroy the active constituents of the drug by decomposing them chemically. This applies especially to leaves and herbs; fungi rarely infest the living tree barks in sufficient numbers to modify their medicinal value.

Drugs which are slowly or incompletely dried or which are stored in damp rooms or containers are almost invariably attacked by hyphal fungi as well as bacteria. The hyphal fungi belong to a group commonly known as moulds. They grow very rapidly; a day often being sufficient to spread through a large collection, the hyphae growing over the surface, into crevices and intercellular spaces, into broken cells, along the path of vascular tissue, finally spreading through the entire tissue. In the case of leaves the hyphae gain entrance into the spongy tissue and palisade tissue by way of stomata and broken epidermis. In the actively growing stage the hyphae are white, presenting a wooly appearance. This whitish growth can readily be seen as it spreads over the drugs. There is also the very marked and characteristic

mouldy or musty odor. If left to itself the fungus finally ceases growing due to a lack of nourishment. The white color due to the presence of the living hyphae then disappears and the attacked portions of the drug gradually assume a darker coloration. Drugs thus attacked are worthless because of the destruction of most of the active constituents. Leaves and herbs are especially liable to be attacked by moulds; to a somewhat lesser degree also larger roots and rhizomes. Not only are crude drugs attacked by these fungi, but powdered drugs, also extracts, tinctures and especially syrups, etc. The spores of the moulds are to be found everywhere and are carried about by air currents, hence it would be impossible to exclude or destroy the spores. It is therefore necessary to prevent their germination and very fortunately this can be done quite readily in the case of vegetable drugs, whether crude or powdered. The greatest foes to the development of fungi, moulds and bacteria in particular, are dryness, cold and sunlight. Therefore, carefully drying all vegetable drugs and storing them in dry containers in a dry, cool and well-ventilated store-room will prevent the development of fungi, though the spores may be present. It is, however, not advisable to keep drugs exposed to sunlight as that hastens the destructive changes of the active constituents.

Microscopically the presence of a fungus, whether spot fungus or mould, is readily detected by the presence of the characteristic hyphae which cannot readily be mistaken for anything else.

### *c. Lichens.*

Lichens are a very interesting group of plants resulting from the symbiotic association of a fungus and an alga. They therefore present the histological characteristics of hyphal fungi and some of the usually single-celled lower algae.

These plants never develop upon the drug itself. When present it may be known that they developed upon the drug-yielding plant before the drug was collected. They are found upon the exterior surface of some unpeeled tree barks. Lichens never develop underground, hence they are not found upon root barks or other subterranean plant organs. Their presence is therefore diagnostic of stem barks, though it must not be supposed that they are found on all stem barks. They appear most commonly as circumscribed patches, varying in size and color (crustose lichens). The predominating colors being ash gray with perhaps a greenish tinge, some are reddish yellow or orange. The apothecia may resemble those of spot fungi or they may be linear (*Graphis*). Sometimes remnants of foliose lichens (*Parmelia, Physcia*) are present; more rarely also remnants of fruticose forms (*Usnea*). The cinchona barks are especially rich in lichens, presenting a mottled appearance due to the presence of the crustose thalli, through which the apothecia are distributed. Some of the smaller more rudimentary lichens closely resemble some of the spot fungi.

The presence of lichens is not indicative of a poor quality of the drug. If present in considerable numbers there is no doubt that a portion of the active constituents of the drug are destroyed, due to the life activities of the lichens. Since lichens are less parasitic (saprophytic) in their mode of living than fungi, they do not abstract such large quantities of assimilation products of the host plant. The host plant serves principally as a physical support rather than a source of food though there is little doubt that some food is supplied to the lichen by the host plant in addition to the assimilation products prepared and supplied by the symbiotic algae (*gonidia*). In any case lichens occur only sparingly upon a comparatively few stem barks and need cause no concern to the pharmacist as regards the value of drugs.

They are principally of botanical interest and, as already indicated, they are of some diagnostic value.

### 2. ANIMAL PARASITES.

The most destructive pests to vegetable drugs are certain animals which feed upon the drugs in containers and storerooms. Some drugs are more readily attacked than others. Those rich in starch, sugar and inulin are especially liable to attack, no matter how poisonous they may be, as strophantus, belladonna root and aconite root.

These parasites belong principally to the insecta and arachnida. Of the insecta the most common is *Sitodrepa panicea*. This is a small beetle about one-fourth inch in length, of a dark brown color. The insect passes its entire existence among the drugs. The larva hatched from the egg is a light colored grub which feeds very voraciously upon the drug for several weeks, then pupates (resting stage) and finally develops into the sexually mature insect (imago), which also feeds upon the drug and lays the eggs from which a new generation springs. As indicated the larva is most destructive. Sometimes almost the entire drug is destroyed leaving only a thin outer shell which crumbles to pieces under the lightest touch.

There are a number of other insect parasites which may be found among drugs. *Lasioderma serricorne* resembles *Sitodrepa* in form and habits. *Ptinus brunneus* is somewhat larger with long antennae; it is similar in habits but seems to show some preference for leaves and leafy herbs and powders. Other comparatively rare insect parasites which occasionally attack drugs are *Bostrichus dactilliperda* and *Anthrenus scrophulariaceae* which are more common upon furs and skins; *Anthrenus varius* generally attacks dried animal substances, particularly furs. *Tenebrio obscurus, Calandra oryza, Tinea penionella* (the ordinary cloth

moth), and a number of other insects may on occasion be found feeding upon drugs.

Of the arachnida there are certain mites which occasionally attack drugs, especially powdered drugs, and such substances as sugar, starch, flour and bran. These animals are very small and closely related to the familiar cheese mites, sugar mites, meal mites, itch mites, etc. As a rule they are nearly colorless and this combined with their minuteness makes it difficult to detect them in the early stages of infection. They occur less frequently than insects and cause serious trouble in only isolated instances.

It does not matter so much what the parasite is. The point of real interest is that drugs, both crude and powdered, may be attacked by various animal parasites; that these parasites are often very destructive and constitute a nuisance sometimes not readily combated. If one keeps in mind that some drugs are more readily attacked than others it will simplify the matter of watching the stock on hand for incipient evidences of the presence of parasites. If mature insects are present it indicates that the drug is infested. Looking over the infected roots and rhizomes one may readily observe small circular openings which the larva make in eating their way in or out of the drug. By means of the powerful jaws the insect converts the drug into a powder, some of which may be found at the bottom of the container or scattered through it. The grub literally destroys the entire interior of the drug, leaving only a thin outer shell which serves as a protection to the insect or larva. The minute round holes of ingress and egress are unmistakable evidence of the presence of the parasites.

The following drugs are most liable to be attacked by animal parasites: Aconite root, angelicum, apocynum, asclepias, belladonna root, calamus, colchicum corm, ergot, ginger, inula, iris, pellitory, rheum, taraxicum, squill, most

of the leaves and herbs. These drugs, whether in the crude state or powdered form, should be inspected frequently; if the parasites are present as evidenced by the presence of the insects themselves, their larvae or powder-like particles of the drug, the retainer should be emptied, the larvae insects and attacked specimens should be removed, drugs and retainer thoroughly cleaned, dried and then replaced. These watchful measures are usually all that is required, but to make sure that all of the parasites are rendered inactive the drug should be exposed to some insecticide which does not destroy or modify the active constituents of the drug nor poison it. Bisulphide of carbon is perhaps the most effective insecticide. It kills the larvae and mature insects, but does not destroy the eggs, hence several inspections are necessary after the insecticide has been used, as eggs may be present from which new larvae develop.

The bisulphide of carbon may be used as follows: Place the cleaned drug loosely in the container or in a roomy dry clean box with tight cover or lid. Pour some of the bisulphide of carbon in a flat vessel and place it in the box containing the drug, close the box and leave the drug exposed to the vapor of the insecticide for several hours or more, the time of exposure depending upon the quantity of the drug.

Pieces of gum camphor placed with the drug are said to drive away insects; it does, however, not kill them. Boxes and containers in which insect parasites have existed should be thoroughly washed and scalded in boiling hot water to kill the eggs that may be present and then thoroughly dried before the drugs are replaced.

Powdered drugs may be treated like crude drugs. Larvae and insects may, however, be more readily removed by sifting; the eggs will of course pass through the sieve with the powder, hence repeated inspection and perhaps repeated

sifting may be necessary. The mature insects of powdered drugs usually work their way to the sides of the glass bottles and other transparent containers where they can readily be detected. The larvae remain in the interior of the powder.

Chloroform and ether may be used like bisulphide of carbon or it may be sprinkled over the drug directly and the container closed. These insecticides must, however, not be used too frequently or too profusely as they undoubtedly destroy some of the active constituents.

In the majority of cases it is best to discard infested drugs, especially powders, as it is not possible to remove the insects completely without much care and trouble.

## III. THE PREPARATION OF DRUGS.

The exact chemical nature of many of the active constituents of vegetable drugs is little understood, nor is their distribution and localization within tissues and cells well known. This applies particularly to the alkaloids. Experience has, however, taught us that while the entire plant may contain the active substance, certain organs of the plant and certain tissues of that organ contain more of the alkaloid, or other active constituent, than any other part or tissue of the same plant, hence this plant portion is collected and prepared for the drug market. Experience has also proven that the amount of active constituents present varies greatly during the vegetative period. The manner in which drugs are prepared also modifies the active constituents, quantitatively and qualitatively. The pharmacist should have some idea of the manner in which drugs are prepared for the market and should realize somewhat the effects these preparatory manipulations have upon the quality of drug or more specifically the effects they have upon the quality and quantity of the active constituents.

## I. TIME OF COLLECTING.

Drugs should be collected during that period of vegetative activity in which the desirable active principle is present in maximum quantity. Unfortunately this period is as yet not accurately determined for many plants. Quantitative chemical analyses in association with experimental physiology would clear up many undecided problems, but such experimental research is slow and difficult of effective execution, hence much remains yet to be done. This quantitative and qualitative determination of active constituents is also greatly hindered by the uncertainty and variation in the methods of collecting, curing, packing, shipping and storing of drugs, due to a lack of intelligent supervision. Ignorant peasants and still more ignorant natives of remote semi-civilized and savage countries follow their own inclinations and fancies regarding the preparation of drugs. The entire manipulation and supervision of drug yielding plants and drugs should be under the direction of intelligent and thoroughly qualified individuals. That such supervision is necessary is evidenced by the fact that a number of medicinal plants are wholly unknown botanically, as for example those which yield sarsaparilla, coto bark, some cinnamons and a few others.

The time of collecting depends upon the part of the plant to be used. In a general way it may be stated that the drug is collected when the plant organ to be used medicinally has reached its full development. Flowers, floral parts, fruits and seeds are collected at maturity. There are, however, exceptions. The flowers of pale rose, lavendula, caryophyllus, santonica, orange; the fruits of poppy, long pepper, elaterium and vanilla; the seeds of pepper and pimenta, cubeb, are collected before full maturity. Most leaves and leafy herbs are collected at the time of flowering or shortly

before that period. According to the French Pharmacopoeia leaves and herbs not having a strong odor as aconite, belladonna, verbascum, stramonium, etc., are to be gathered shortly before blossoming, while aromatic leaves and herbs as tansy, absinthium, mints, etc., should be collected at the time of blossoming.

It is wholly reasonable to assume that the time for collecting leaves, herbs, flowers, fruits and seeds will depend upon whether they are desired for the substances which are the product of direct protoplasmic activity (metabolism), as alkaloids, glucocides, inulin, etc.; or secondary products arising from the breaking down of formed materials, as volatile oils, resins, gums, etc. If the former substances are desired the plant parts should be collected at the time of greatest vegetative (protoplasmic) activity, as indicated (with few exceptions), but if the second kind of substances are required then the plant organs should be collected shortly after the period of greatest vegetative or protoplasmic activity, as in the case of eucalyptus leaves.

With subterranean organs as roots, rhizomes, tubers, bulbs, also the barks of trees and shrubs, the time of collecting is more at variance. In the fall of the year the subterranean organs of perennial plants of the temperate zones contain a maximum of substances elaborated by the aerial plant organs, the leaves in particular. They are deposited as reserve food-substances to be again utilized in the succeeding spring when the subterranean organs are again freed from the deposited food-substances. From these statements one might be led to believe that the proper time to collect the plant organs referred to would be in the autumn. This is true in many instances, but there are numerous exceptions. Belladonna roots gathered from the blossoming and fruit-bearing plants (July) are twice as valuable as those collected in March or in October. The roots

of taraxicum, valerian, gentian, angelica, tormentilla, and others, should be collected in the spring. According to some authorities valerian and taraxicum should be collected in the fall, also the roots of symphetum, acorus and bulbs of squills. Aconite roots should be collected from the flowering plant.

In the case of biennial and perennial plants it is also necessary to consider the age of the plant. Roots of woody plants (trees and shrubs) should be collected from fully matured specimens, usually late in the autumn, after the falling of the leaves. Roots of perennial herbaceous plants should be collected during the second or third year (calamus asarum, inula, licorice). Roots of biennial plants should be collected in the fall of the first year. As a rule barks contain most of the active principle in the fall of the year, or in the early spring before active metabolism has set in. The time of collecting also depends upon the active constituents it is desired to obtain. For example the younger cinchona barks are richer in cinchonin and tannic acids, and poorer in chinin than the older barks. Younger cinnamon barks are richer in ethereal oils than the older. Young oak bark contains more tannin than the old bark.

As a rule leaves are collected at maturity, as indicated, without any special reference to the age of the plant. In some instances (biennial and some perennial plants) there are specific directions as to the year when the leaves should be collected. Digitalis leaves and hyocyamus leaves should be collected from plants of the second year's growth (period of flowering). The younger dorsiventral leaves of eucalyptus are not to be included. The best tea is obtained from the exceedingly young leaves and terminal branches. The best coca leaves are picked from shrubs three to five years old.

2. PREPARATION FOR CURING.

Immediately after collecting various drugs are artificially

modified preparatory to curing or drying. Some of these manipulations are necessary or useful, while others are unnecessary or perhaps merely for the purpose of satisfying the aesthetic fancies of dealer or consumer. This applies, for example, to the repeated washing of Jamaica ginger for the purpose of increasing its whiteness, the coloring of tea, by means of Paris green and indigo, and the coloring of the coffee beans. Most of the manipulations are, however, useful or highly essential, and should be conscientiously applied by collectors and others concerned. The following are the more important manipulations of collected drugs preparatory to drying:

1. *Washing.*—All drugs should be freed from extraneous, undesirable matter which may cling to them. This applies particularly to subterranean organs, which must be freed from the soil, sand, foreign roots and rootlets and other foreign organic particles. Most of the soil may be removed by brisk shaking, especially if the soil in which the plants have been grown was comparatively rich in sand and not very wet at the time of collecting. Wet alluvial soil clings quite tenaciously and after drying it "bakes" and clings still more firmly. Soil particles that will not come away by shaking should be removed by washing in clean water. In many instances the removal of soil is grossly neglected, especially of roots and rhizomes. This delinquency may be due to carelessness, indifference, ignorance and to uncleanly habits of collectors. Mexican sarsaparilla is quite generally very dirty. The same may be said of the American roots as gentian, taraxicum, serpentaria and others. In some instances the soil is allowed to remain for the purpose of adding to the weight of the drug.

In a few instances washing is undesirable or carried to extremes. According to several pharmacopoeias the roots of artemisia are not to be washed. In Jamaica the peeled

ginger rhizomes are placed in a tank or tub of water for twelve or twenty-four hours, which is said to increase the whiteness of the article, which is doubtless true, but the prolonged soaking and washing removes much of the active constituents.

Bits of foreign vegetable particles, foreign roots and rootlets, which may have been collected with the subterranean drugs, should be removed by hand before washing. Leaves, flowers and other plant organs growing above the ground should never be washed as that destroys much of the active principles and gives the drug a dark color.

The slightly musty odor of subterranean organs is due to the presence of soil particles; an odor which becomes more pronounced upon moistening the drug. Naturally the odor increases with the proportional amount of soil present; as stated, it is very marked in sarsaparilla and some other roots.

2. *Garbling.*—Garbling consists in the sorting of the drug; that is the removal by picking, sifting or winnowing, of undesirable parts or particles. Careful garbling gives the drug a clean wholesome appearance and adds greatly to its commercial as well as medicinal value. Just what should be culled out or removed will depend largely upon the plant parts desired. If only the rhizomes are desired (calamus, iris, ginger) then all roots and stem remnants should be carefully removed. In the case of roots, as ipecac, stem remnants should be excluded. In the case of herbs and leaves, dead and dried, diseased and highly discolored specimens should be removed.

Garbling need, however, not be carried to extremes; small, stunted or otherwise slightly abnormal specimens need not necessarily be discarded as they usually possess full medicinal value. There is, however, no doubt that

such exclusion will enhance the appearance and salability of the drug.

Most seeds, the spices in particular, are winnowed, which removes stem and leaf remnants, specimens defective in weight, etc. Unfortunately the refuse obtained from winnowing is often powdered and mixed with other powders of the same drug or sold separately. The larger and heavier seeds and fruits, as coffee and juniper berries, should be gone over by hand after winnowing, to pick out diseased specimens, pebbles and other larger and heavier particles which could not be removed by blowing.

In some instances the garbled article has intrinsic value and is retained and placed upon the market separately, as the mace of nutmeg, the hulls of cocoa, tea dust, etc.

3. *Peeling.*—Peeling or removing the outer, usually suberized, tissue layers of some of the larger roots, rhizomes and other plant organs is generally resorted to as a step preparatory to drying. This process subserves several purposes, of which the most important is that of hastening drying. The special function of the epidermis and suberized cell layers is to reduce to a minimum the evaporation of moisture from the interior of plants; therefore as soon as these tissues are removed moisture escapes very rapidly and the drug dries quickly, which is not only time saving, but also lessens the opportunity for the development of bacteria moulds, mildews and other fungi as well as animal parasites.

Occasionally peeling is for the purpose of removing parts which are of little value medicinally, as the outer layers of ulmus, quillaja, cinnamon, juglans and the rind of colocynth. In some instances peeling removes the tissues richest in active constituents, as in calamus and ginger.

Peeling, which is usually performed by hand with the aid of a knife, may be only partial, as in the case of some

ginger and male fern stipes, or complete, as in the case of most Jamaica ginger, calamus, Florentine iris, colocynth fruits, etc. Some seeds, as black pepper, are occasionally partially decorticated apparently for no special reason.

4. *Cutting.*—Instead of peeling most of the larger and fleshy roots, rhizomes, bulbs and tubers are cut into pieces of variable size to hasten drying. This method is more rapidly executed than peeling and does not waste any of the substance. The larger roots of gentian, levisticum, and belladonna are usually cut longitudinally; calumba and colchicum are generally cut transversely; inula, zedoary, rheum are cut transversely, longitudinally and diagonally. The bulbs of squills are cut longitudinally and transversely after the papery outer leaves have been removed.

It should be kept in mind that peeling as well as cutting exposes the tissues containing the active constituents to climatic influences which hasten their evaporation, dissipation and chemical decomposition. These influences are, however, not so far-reaching in their destructiveness as those which would in all probability follow as the result of retarded or prolonged drying. The presence of moisture in dead cells is very destructive to their chemical constituency, as will be explained more fully in another chapter; drugs should therefore be dried as quickly as possible.

5. *Scalding.*—A few drugs (salep, curcuma, some ginger) are placed in boiling hot water before drying. This process serves three quite important purposes. 1. It kills all cells and prevents sprouting. 2. It destroys all parasites that may be present. 3. Destroying all cell life hastens drying as moisture escapes much more rapidly from dead cells than from living cells.

If such scalded plant organs contain starch it is converted into paste, at least in the outer tissue layers. A microscopical examination at once reveals the presence of the

pasty or dextrinized nature of the starch by the absence of characteristic form of the starch granules as compared with those which occur in the unscalded portions of the drug. If the tissue is quite rich in starch it shows a glossy fracture and becomes somewhat darker in appearance.

6. *Coloring.*—Coloring of drugs preparatory to drying is practiced occasionally, the object of such coloring being to give the article a more desirable and hence more salable appearance. Formerly tea was quite generally colored a darker green with Paris green and indigo, a custom largely practiced in northern China and apparently initiated by the natives themselves. While, as stated on good authority, not enough Paris green is added to be harmful it is nevertheless a custom which should be condemned as the coloring adds nothing to the quality of the tea and is primarily intended to deceive the buyer and consumer.

It is stated that a large proportion of coffee beans placed upon the market are colored a bright green to give the impression of uniformity of quality, which usually does not exist. Collectors and merchants recognize the fact that the bright green not fully ripened beans are preferred, hence the custom of coloring those which are brown and more mature.

It is, however, gratifying to note that only few drugs are colored and that consumers are learning to prefer the genuine uncolored article.

7. *Liming and Bleaching.*—A few drugs (ginger, nutmeg, calamus, orris rot, althaea) are subjected to a process of liming by placing them in water containing lime so that the particles will penetrate all of the crevices and form a coating over the entire surface, which remains for some time after drying. The lime destroys all animal and vegetable parasites that may be present and prevents their development as long as the coating of lime remains. Since the lime is readily shaken off or worn away by friction it may be

necesary or advisable to relime from time to time. In some instances liming is done by simply rolling the specimens in finely powdered lime. More generally liming is done both before and after drying.

Bleaching is in a few instances resorted to for the purpose of increasing the whiteness of the article, but this practice is certainly of rare occurrence. Ginger is said to have been bleached with chlorine gas and fumes of burning sulphur. Bleaching adds nothing to the value of the drug, in fact the process is to be condemned, as it destroys much of the active constituents. While lime is not a desirable ingredient of drugs it serves a useful purpose as an insecticide.

### 3. CURING OR DRYING.

Drying or curing consists in exposing the collected, cleaned, garbled, cut and otherwise prepared drug to a more or less high temperature for the purpose of removing the greater part of the moisture present. The methods of curing are very variable, depending upon time, place, opportunity and the nature of the drug. The methods employed by the large planter are more uniform, more satisfactory and more scientific than those employed by the small planter. The temperature employed varies from the more or less variable shade temperature and direct sun temperature of the country in which the drugs are collected and dried, the artificial uniform temperature of large drying ovens employed by the more progressive large planters, to the high artificial temperature employed in roasting coffee and in drying jalapa. We can only enter into a general consideration of the various methods.

#### *a. Changes Induced by Drying.*

Only a few vegetable drugs are used in the fresh state (mulberry, raspberry, garlic, aconite leaves, violet flowers),

or undried drugs contain a maximum of active constituents. though with few exceptions (valerian, frangula) the living Curing or drying is always done at a sacrifice of active constituents. The necessity of drying becomes apparent when we recognize the fact that most drugs are grown great distances from the manufacturer and consumer; they must therefore be prepared in such a way as to preserve their activity, while in passage and while in storage. Nothing is more detrimental to the permanency of the various active constituents than the moisture which occurs normally in cell-walls, cell-lumen and intercellular spaces of all parts of the dead plant. The amount of moisture present varies greatly in different plants and in different plant organs. Young, hence not fully matured, plant organs are richest in moisture. Young *Lactuca* leaves contain only about two per cent of dry substance, while the older leaves contain from ten to thirty per cent of solids. The amount of moisture varies similarly in young leaves, herbs, flowers, barks and twigs of plants in general. Matured woods, roots, rhizomes and barks contain much less moisture than leaves, herbs and flowers. Seaweeds (*Chondrus crispus*) contain a high percentage of moisture—seventy-five to eighty per cent. Dry fruits, rich in starch, as the cereals, contain only about fourteen to fifteen per cent of moisture. Fleshy fruits contain from seventy-five to ninety-five per cent; in roots, tubers and rhizomes the amount of moisture varies between sixty and eighty-five per cent. Plants grown in wet soil contain a higher percentage of moisture than similar plants grown in comparatively dry soil.

The moisture which is driven off in the process of drying causes a diminution in volume, weight and form directly proportional to the amount of moisture which was present. The modifications in form are most marked in the tissues richest in moisture and adapt themselves somewhat or cor-

respond to the structural characteristics of the tissues containing least moisture. In roots, rhizomes and stems longitudinal wrinkling is most noticeable. Some wrinkling may also extend horizontally and diagonally. Wrinkling and pitting of some fruits, as pepper and cubeba, is quite characteristic. Horizontal fissuring is occasionally quite marked, as in ipecac and apocynum. The shrinking of the leaf-parenchyma causes the veins to stand out more prominently. Barks curl inward (quilling), due to the fact that the tissues nearer the cambium contain more moisture and hence shrink more on drying.

Drying causes all tissues to become more brittle, less tenacious and fibrous. Even plant organs with considerable bast tissue (cinchona, cinnamon) may appear quite brittle when thoroughly dried. Tissues rich in starch become mealy (colchicum corm, sarsaparilla and belladonna root). Roots and rhizomes free from starch and rich in inulin become glossy and brittle.

Drying causes extensive chemical changes in vegetable tissues; of these changes many are but little understood. Glucocides and related compounds in particular undergo decomposition under the influence of the free oxygen of the atmosphere. It is highly probable that many of these decomposition changes are due to bacterial action, as already indicated. These changes in part also bring about the change in color which drugs undergo during drying; much of the variation in color is, however, also due to loss in moisture, as may be determined by moistening the dried drug and noting the partial return of natural color.

The quality and quantity of the odor is also greatly modified by the drying process. In some instances the characteristic odor of the fresh drug disappears almost entirely or becomes greatly reduced, as, for example, the nauseous odor of the leaves of the many of the Solanaceae and the leaves

of digitalis, the alliaceous odor of squill, the horseradish-like odor of aconite. In some instances drying develops an odor in drugs which are practically odorless when fresh, and in other instances the odor is changed qualitatively.

The process known as sweating develops a new and characteristic odor of certain vegetable substances, as the flavor or aroma of tobacco, of tea, and of vanilla. Sweating removes the astringency of cocoa beans. Roasting develops the aroma of coffee and chicory. In sweating and roasting the aroma is the result of oxidation processes, in the former case induced by bacteria, in the latter case by the high temperature.

Even after the most careful and thorough drying, plant tissues contain some moisture and reabsorb yet more from the atmosphere (hygroscopic moisture). Vegetable tissues are hygroscopic and the amount of moisture absorbed will depend upon the plant or plant organs, upon the amount of atmospheric moisture present and the manner in which the drug is stored or packed. Roots and leaves contain on an average from nine to sixteen per cent of hygroscopic moisture; herbs and flowers from ten to fourteen; barks from nine to fifteen; stems from ten to twelve, and seeds about ten per cent.

The following is a brief summary of the more important chemical changes which drugs undergo during drying:

1. Dried drugs do not represent the full medicinal value of the plant or plant organ. The generation of valuable chemical compounds during drying or subsequent thereto is exceptional, as valerianic acid in valerian, frangula and hops; the aroma of coffee, tea, tobacco, etc.

2. The more important alteration produced by drying consists in the dissipation of a portion of the volatile constituents and the oxidation of some of the fixed and volatile constituents. During drying the moisture in the cells and

intercellular spaces is replaced by air charged with more or less moisture, which moisture is absorbed by the hygroscopic portions of cells and cell-contents, causing a slow but continual decomposition of active constituents. This explains why porous drugs deteriorate more rapidly than those which are more firm in consistency, and also explains the gradual deterioration of all drugs, powdered drugs in particular.

3. To reduce the injurious influence of hygroscopic moisture (atmospheric moisture), drugs should be dried quickly and then firmly compressed in dry containers and stored in dry storerooms.

*b. Manner of Drying.*

Most small planters place the prepared drugs upon elevated hurdles exposed to the air and sun; or they may even be placed upon the ground, which is first smoothed down and covered with leaves or brush, on which the drug is spread. On the larger plantations are found large tiled or paved floors, kept clean and dry, upon which the drugs are dried. There are sheds on all sides of this floor, into which the drugs are swept or carried at night or upon indication of rain. In some instances the floor is roofed over to keep out rain, yet permitting free circulation of air.

During bright dry days the drugs are exposed upon the floors or hurdles referred to, a few hours after sunrise, when the dew and atmospheric moisture has dissipated. During the day they are turned several times. In the evening they are again placed under cover. This is repeated day after day until the drug is well dried.

Many drugs are exposed to direct sunlight, especially those collected by natives in barbarous and semi-barbarous countries. As a rule, shade-dried drugs are preferred, as direct sunlight hastens chemical changes in cell-contents.

Sun-dried material, however, usually presents a brighter, cleaner and more salable appearance.

Artificial heat is frequently employed by placing the drug in large ovens, kept at a temperature of from 30 to 50 degrees C. The ovens are so constructed as to permit free circulation of air, the material being placed upon perforated compartments. Occasionally the preliminary wilting or drying is done in the air and the final and complete drying is done in ovens. Leaves and herbs are spread out in thin layers and air-dried. Fruits and seeds may be air-dried or dried in ovens. Barks are quite generally air-dried. Most subterranean organs are air-dried, also in ovens. Jalap, sarsaparilla and China root are generally dried over a flame. Jalap is quite often dried over a slow fire and smoked, which explains the "smoky" odor of that drug. In drugs dried at high temperature it is remarkable to find that the outer tissue layers, which contain starch, show the presence of normal granules, while the starch of the interior cells is pasty. This phenomenon has been erroneously cited as evidence that pasty starch is of normal occurrence in certain plants. The starch of the outer tissue layers is not dextrinized or converted into paste because the heat drives off the moisture before the temperature is sufficiently high to modify the granules; the moisture from the interior cannot escape rapidly enough; therefore the starch is converted into a paste.

Some drugs are dried in the interior of houses behind stoves and near fireplaces; this applies especially to rhubarb from Russia and Tartary, where it is customary for the peasants to puncture holes through the masses of large, irregularly cut roots and, stringing them like beads, hang them over the fireplace or large brick ovens of those countries. Salep tubers are frequently dried in a similar way. Occasionally drugs are dried in the baking oven, as curcuma, jalap and salep. This method is, however, only resorted to

by small planters, who evidently make the cultivation of drugs an incidental occupation.

The prime object to be attained in drying is to remove the moisture, as already stated. While water is absolutely necessary to the development of plants and their constituents, it is very detrimental to these constituents in dead plants and plant organs. The presence of moisture in dead tissues initiates chemical disintegration very promptly; it is therefore desirable to remove this moisture as rapidly and completely as possible. Occasionally it is desirable to check the escape of moisture so as to induce fermentative changes (sweating). The fermentation is initiated by placing the wilted and partially dried material in large heaps until the desirable change in aroma, flavor or taste has taken place, after which drying is completed in the usual way.

No matter how carefully drying or curing may be done, there will be a loss of active constituents; but this unavoidable loss is insignificant as compared with the loss which would follow if any considerable moisture were present. Bacteria, moulds and mildews would develop within a very short time and destroy the drug. Curing should, however, not be hastened by the use of high temperatures or hot-air blasts, as that would cause excessive oxidation and volatilization of active constituents. Great care and good judgment are necessary in order that drying may be most effective.

### 4. MANIPULATIONS PREPARATORY TO MARKETING.

For purposes of convenience in handling, marketing and storing, drugs are variously prepared, usually before drying. Long, fibrous roots, as sarsaparilla and menispermum, and fibrous barks, as rubus, mezerion and willow, are variously rolled or folded into bundles of convenient size and form. The thin quills of Ceylon cinnamon are rolled over each other or partially telescoped. In removing barks from trees (cinchona, cinnamons, frangula, ulmus, quercus,

juglans, etc.) the sections are made of suitable length and width, depending somewhat upon the thickness of the trunk or branches, the thickness of the bark and the readiness with which the bark is removed. Most barks are removed in rather small, irregular pieces or chips, especially the clinging barks (cherry bark, sarsaparilla, viburnum, cascarilla, canella, aspidosperma, etc.).

Garlic bulbs are strung to a core of straw. Each core is about one foot in length, carrying from twenty-five to thirty bulbs. Scoparius and chirata are usually tied in bundles of the size of a handful. Woods are variously prepared; some are cut into billets of convenient size or reduced to a coarse powder by rasping. In some countries it is cut into small, regular cubes. More generally it is simply cut into small diagonal chips.

These manipulations are largely for convenience in handling, but due regard should also be given to their effects upon the quality of the drug; but, unfortunately, this is not always done. Some of the preparations for drying or curing are also done for convenience in handling and shipping; others will be referred to under preservation of drugs.

### 5. PRESERVATION OF DRUGS.

As already indicated, vegetable drugs deteriorate gradually, due to the volatilization and decomposition of active constituents. There is no way of preventing such gradual and continued loss, but under certain conditions the same drugs will retain their medicinal properties longer, or, rather, will lose them less rapidly than under other conditions. In the preservation of drugs due attention must be given to those influences which cause the destructive changes referred to, as air, heat, moisture, light, animal and vegetable parasites, etc. Of these factors, moisture is undoubtedly most injurious. Special efforts should therefore be made to keep the drugs dry.

They should be kept in dry containers and stored in dry storerooms, after being thoroughly dried. The containers should be kept entirely filled, to exclude air as much as possible. Some drugs must be more carefully guarded against moisture than others, especially the more hygroscopic plant organs, as gentian, inula, taraxicum, levisticum and squills.

Leaves, flowers and herbs keep much better when quite tightly compressed and kept in pasteboard containers. To remove hygroscopic moisture and atmospheric moisture, fused carbonate of potassa may be introduced into the containers in flat iron trays. Larger plant organs, which cannot readily be compressed, as barks, woods, roots, rhizomes, seeds and fruits, should be packed as tightly as possible in dry wooden or pasteboard containers. Powdered vegetable drugs should be kept in bottles entirely filled and tightly closed. Hollow glass stoppers containing lime are recommended.

To guard against infection by animal pests it is advisable to sprinkle a little ether or chloroform over the drug from time to time. It is not advisable to place crude drugs and most powdered drugs in hermetically sealed containers, as renewal of atmosphere is necessary to reduce the liability of the development of vegetable parasites.

Drugs with very volatile constituents keep much longer in hermetically sealed glas or tin containers, provided such drugs are carefully dried; otherwise they would deteriorate even more rapidly than when kept in wooden or pasteboard containers.

Drugs should not be exposed to sunlight, since this agency is almost as destructive to active constituents as is moisture. Crocus, cusso and lupulin especially should be kept in the dark. Because of the greater surface exposure, powdered and otherwise reduced vegetable drugs deteriorate much more rapidly than crude drugs.

Drugs are very frequently ruined in shipping, though they may have been carefully collected, cured and packed. The stay in ship holds, in freight trains and freight offices, where the necessary precautions as to dryness and temperature cannot be observed, or are disregarded through negligence, is in many instances the cause of the worthlessness or poor quality of the drug. It is much to be regretted that the collecting, drying, packing and shipping of drugs is not done under more careful supervision and direction.

It must, however, be kept in mind that in spite of the greatest precautions in the entire manipulation of drugs they lose their medicinal virtues in a comparatively short time. The leaves of belladonna, digitalis, hyoscyamus, melissa, the mints, stramonium, belladonna root, male fern, lupulin, ergot, colchicum seeds and some other crude vegetable drugs should be renewed annually. Others need not be renewed so frequently, but nearly all drugs become worthless in two or three years. It must also be remembered that a few drugs are inactive in the fresh state, as frangula, which must be one year old before the active principle is sufficiently developed. As will be explained more fully later, powdered drugs deteriorate very rapidly, much more rapidly than crude drugs, for which reason special precautions should be observed in their preservation and preparation.

### 6. CULTIVATION AND CLIMATIC CONDITIONS.

Habitat, cultivation and climatic conditions have a great influence upon the activity of drugs, factors altogether too frequently overlooked or insufficiently valued. The change in active constituents of a given drug, due to these factors, may be qualitative or quantitative, or both. The rhizomes of valerian from open, dry, mountainous regions are much richer in etherial oils than those grown in shaded, moist places. The same may be said of herbs rich in ethereal oils.

Taraxicum grown in sterile soil is much richer in bitter principles than that grown in rich soil. The odor of the labiates is qualitatively and quantitatively altered by differences in fertility of soil, locality and moisture.

Cultivation has a very marked influence upon the activity of some drugs. In some instances the activity is increased and in other instances it is decreased. For instance, the cinchonas cultivated in the East Indies are richer in alkaloids than the cinchonas native of South America. The stem portions of many labiates, the subterranean organs of many umbelliferous plants and of other cultivated medicinal plants are richer in resinous and ethereal constituents than the wild growing plants. On the other hand, cultivated aconite is far less active than wild aconite. Cultivated cichorium loses its bitterness almost entirely. The leaves of wild *Hyoscyamus niger* contain less hyoscyamin than those of the cultivated plant.

Indian hemp grown in India develops its active constituents to a maximum degree, while the hemp grown in the temperate and subtropical countries of Europe and America is almost entirely inert. The poppy cultivated in temperate countries yields less opium than that grown in India or Turkey, though the quality is the same. The pharmacopoeias should be more specific in regard to the influences of the above factors. Further reliable research work is also necessary to clear up many disputed and unsettled questions regarding the matter.

### 7. POWDERING OF VEGETABLE DRUGS.

Most crude vegetable drugs must be reduced to a powder for the purpose of the ready extraction of active constituents. The student of pharmacy and the practicing pharmacist should therefore be competent to pass judgment upon the quality of simple vegetable powders, but, unfortunately, the United States Pharmacopoeia and the various

text-books on vegetable pharmacognosy do not give any descriptions, either general or special, of powdered drugs. The following suggestions are intended to serve as a guide in the study and examination of vegetable powders, including ground spices, coffee, chicory, tea dust and such other vegetable substances as normally appear in the powdered, crushed or reduced form, as lupulin, kamala, lycopodium, crocus, guarana, dextrin and starches.

1. *Selection of Drugs for Powdering.*—Vegetable drugs to be powdered should be of good quality, well garbled and free from dirt, dust, lime, sand and other undesirable substances. The quality of the drug is of special importance because it would be very difficult, if not wholly impossible, to distinguish a good quality of powder from a powder prepared from an inferior or worthless drug. Both would present the same histological characteristics, though there may be more or less marked differences in color, odor, taste, weight and consistency. It would be a very simple matter for the unscrupulous to powder winnowings, refuse, drugs of poor grade, and place them upon the market as the genuine article. Even the exhausted powders might be mixed with the fresh powder without fear of detection unless subjected to a careful chemical and microscopical examination. We shall again recur to this subject under the head of adulterations.

2. *Preparing Drugs for Powdering.*—Before crude vegetable drugs are powdered they are again dried to remove hygroscopic moisture; this is for the purpose of rendering the process of powdering easier, as the tenaciousness of vegetable tissues increases with the amount of moisture present. It should also be kept in mind that low temperatures increase the brittlenes of vegetable tissues. It might therefore prove advantageous to powder the drugs during very cold weather or in an artificially reduced temperature.

Since uniformity of the strength of the percolate depends largely upon the uniformity in the fineness of the powder, it is evident that conditions for powdering crude drugs should be uniform, especially as to temperature and dryness. Drying should be done at a constant moderate temperature (40 degrees C.) in order to reduce the loss of active constituents. Gas ovens with thermo-regulators are most suitable.

3. *Powdering.*—For purposes of reducing vegetable drugs various drug mills are used. In some instances a mortar and pestle are sufficient. Whatever the apparatus employed, it should have the desired operative effectiveness, irrespective of size and working capacity. The larger, more carefully constructed mills, however, yield the most uniform powders. It is practically impossible to prepare a uniform powder by means of pestle and mortar, although this apparatus is highly recommended by some authorities. It is a tedious process and the more delicate tissues are reduced to a fine powder long before the more fibrous portions begin to be broken up. In fact it is practically impossible to reduce bast, tracheids, vessels and similar tissues to anything like a fine powder. Some authorities suggest that this difficulty may be overcome by separating powders thus prepared into three grades as to fineness, and in percolating to place the finest powder at the bottom of the percolator. This suggestion is, however, not practicable, as will become self-evident upon careful consideration.

4. *Sifting.*—The fineness is determined and measured by passing the powders through a sieve with meshes of known dimensions. These meshes should be uniform and square and their dimensions should indicate the size of the opening, irrespective of the diameter of the wire, silk, hair or other substance employed in sieve construction. Here again it is found that the larger machine-operated sieves are more satisfactory than the smaller hand sieves. Sifting should be

done carefully. It is necessary to clean the sieves frequently, as very fine particles cling to the wire, silk or hair, especially at the angles, thus allowing only particles to pass through which are considerably smaller than the free mesh.

The fineness of powders is indicated by the diameter of the meshes given in the metric system or English system, representing a definite number of meshes to the centimeter or to the inch.

The homogeneity and fineness of the powder is greatly modified by the force with which the sieve is operated. Sifting lightly allows only the finer particles to pass through; upon shaking the sieve with greater force coarser particles pass through also. Sieves should be kept closed so as to prevent loss of powder and also to prevent inhalation of poisonous and irritating drugs.

5. *Uniform Powdering.*—All parts of the drug should be reduced to the same degree of fineness. Typical starch-bearing parenchyma is reduced much more readily than any other tissue, long before the more tenacious tissues, as bast, tracheids, vessels, etc., begin to be finely crushed. As the less resisting tissues become reduced sufficiently they should be removed by sifting and the remaining fibrous tissues should be reduced until all will pass through the sieve. With some drugs it is possible to separate the parenchymatous, medicinally active tissues from the fibrous and medicinally inactive tissues, as with ipecac. Some pharmacopoeias recommend that this be done. It is, however, a process not readily put into practice, and hence is not generally carried out even with the few drugs where such a process would be possible.

6. *Mixing of Powders.*—After grinding and sifting, the powder should be thoroughly mixed in order that the comparatively active and inactive particles may be distributed uniformly; otherwise one portion of the powder might be

more active than another portion. Upon standing for some time and during shipment the heavier particles become more or less separated from the lighter particles. It is therefore advisable to thoroughly mix the powder again just before a portion or all of it is to be used.

7. *Fineness of Powders.*—The fineness of the powder will depend upon its intended use. Theoretically it may be stated that the finer the powder the quicker and more complete the extraction of active constituents, no matter whether intended for internal use, for alcoholic extraction or for aqueous extraction. The active constituents occur in the cell-lumen and in the cell-walls; the individual cell should therefore be broken that the extractive substance, whether it be the saliva, gastric juice, alcohol or water, may permeate the cell-wall and occupy the cell-lumen and take up (by solution and asmosis) the medicinal principles. Theoretically, therefore, all cells, whether long, tabular or isodiametric, should be separated from each other and each cell should be broken in two. This would imply that the various drugs should be reduced to very fine powders. Such a condition exists practically in so-called meals, as flour, almond meal, insect powder and most powders intended for internal use. Upon making a microscopic examination of powders designated as No. 80 and No. 100, it will be found that cell groups still remain. It must also be kept in mind that the cells of different drugs vary considerably in size. Drugs from aquatic plants, semi-aquatic plants and plants growing in marshy soil have larger cells than drugs from plants growing in dry soil; hence the powders of the former drugs need not be so finely reduced as those of the latter.

While vegetable powders cannot be too fine from a theoretical standpoint, it is found that for practical purposes of extraction (percolation) the finest powders are not available.

The small particles pack together so closely as to check or prevent percolation.

Powders intended for internal use cannot be too fine. As regards the fineness of powders for the preparation of infusions, extracts and tinctures, it may be stated that for alcoholic extraction the fineness must be greater than for aqueous extraction, since alcohol does not penetrate and permeate cell-walls so readily as does water.

Some drugs cannot readily be reduced to a fine powder directly, as, for instance, seeds rich in oil, as nutmeg, croton beans, castor beans, almonds, cardamom and other aromatic seeds. The oil is first removed and the powdering done subsequently, or some inert substance is added, as sand, sugar, starch, or dry, woody substance, which serves as a comminuting menstruum. Orange peel, lemon peel, slippery elm, mezerion, etc., are first chopped into small bits, dried and then powdered in the usual way.

In the United States the size of the meshes of the sieves or the fineness of the powders is indicated in the English system. Very fine powders, exceeding 100 meshes to the linear inch, are usually designated as dusted powders or meals, and are intended for internal use or other special use, as insect powders. Nos. 80-100 are also largely intended for internal use, but may also be employed for alcoholic percolation. Nos. 50 and 60 are more generally better suited for percolation. For aqueous extraction coarser powders are suitable, as Nos. 20-40. For decoctions, broken drugs or even entire drugs, as leaves, leaflets and some herbs, may be employed.

In Europe the number of meshes are given in the metric system. In Germany, for instance, 5 to 15 meshes to the centimeter indicate coarse powders; 20 to 25 meshes, medium, and 30 to 50 meshes, fine powders. Sieves for fine powders are usually made of silk thread, horse hair for

medium powder and wire for coarse powders. The fineness of the material used should harmonize more or less with the fineness of the powder. The hygroscopic moisture of the powder and that of the sieve threads interferes very materially with uniform sifting, hence the necessity of keeping powder and sieve dry and cleaning the sieve repeatedly. Repeated cleaning is especially required when sifting oily powders.

8. *Preservation of Powders.*—As already indicated, powdered drugs deteriorate much more rapidly than crude drugs; it is therefore urged not to powder drugs until required for use and never to powder more than can be used within a comparatively short period. Some powders deteriorate more rapidly than others, just as some crude drugs deteriorate more rapidly than others. It is much to be regretted that some uniform and efficient method of powdering, packing, shipping and storing is not enforced. Each package or bottle of the vegetable powder should have upon it a statement of the age of the drug from which the powder was made, date of powdering, and when it should be renewed. Some effective method of compensating for loss of active constituents should also be recommended.

After grinding, the powder should again be carefully and thoroughly dried at a moderate temperature and immediately placed in perfectly dry, well-stoppered bottles or other suitable containers.

9. *The Characteristics of Vegetable Powders.*—Since vegetable powders are readily subject to deterioration and adulteration, it is quite important that the pharmacist should be able to recognize the characteristics of pure powders. While the odor and taste are the same in quality as that of the crude drug, it should be kept in mind that these properties are quite less quantitatively. The

odor in particular dissipates very rapidly. Attention should be given to fineness, consistency and weight. If powders of oily drugs are dry and mealy it indicates that the oil was removed previous to powdering. If the powder is deficient in weight it indicates that winnowings or a poor grade of drug were used.

The color of the powder is, of course, uniform and harmonizes more or less with the predominating color of the crude drug, but it must be remembered that the color varies greatly. For instance, exposure to light deadens the color quite rapidly, the tendency being toward grayish shades and tints. Exposure to moisture and the presence of vegetable parasites produces darker shades. The fineness of the powders also greatly modifies the color, increased fineness producing tint effects. In some instances the quality of the color is even changed; for instance, powdered licorice of medium fineness is yellow, while the licorice meal is much lighter, with a decided lemon color. Roasting produces dark to nearly black colorations.

Powdered vegetable drugs may be grouped according to the following colors:

I. Very Light. Mostly seeds and roots.
   1. White, as starches and cereal flour.
   2. Very light, tinged with yellow, red or some dark substance, as althaea, orris root, colocynth, etc.

II. Yellow. Mostly roots and rhizomes. A few flowers and barks.
   1. Pale yellow and straw yellow.
   2. Orange yellow and lemon.
   3. Brownish yellow and yellowish brown.

III. Green. Mostly leaves and herbs.
   1. Greyish green.
   2. Brownish green.

IV. Grey. Mostly roots.

1. Ash grey.
2. Brownish grey and dark grey.

V. Brown. Mostly barks.
1. Reddish brown.
2. Dark brown.

VI. Very dark. A few barks, as juglans. Roasted drugs.
1. Very dark, tinged with red or yellow.
2. Black, as charcoal.

Some of the vegetable drugs give color reactions with certain chemicals (strong solution of potassium hydrate and sulphuric acid), which are more or less useful in determining the identity and purity of the powder.

Since the gross characters of powdered vegetable drugs are variable and otherwise unreliable, the pharmacist must look to other and more reliable characters. The histological elements of drugs are not materially changed, no matter what the changes in color, odor, taste and weight may be. A careful microscopical examination is the only reliable means of determining the identity of a powder, but here also difficulties are met with, as shall be indicated in the following chapters.

The methods of microscopic examination should be uniform for the different powders, and great care is necessary to avoid confusion. The examiner will not be able to obtain reliable results unless he is familiar with the histology of plants and has the ability to recognize different cell-forms in whatever position they may be found. In the case of vegetable powders it will be found that the elongated element, as bast, tracheids, vessels, wood cells, etc., occur in longitudinal view. Parenchyma cells and similar elements occur in fragments and in isodiametric groups. The size of the cell-groups will, of course, depend upon the coarseness of the powder. For microscopic examination the most suitable fineness is No. 40 to 60 for low powders and about

No. 80 for high powder work. Very fine powders, No. 100 and finer, are rarely desirable for microscopic work. For more detailed directions regarding the microscopical examination of powders and crude drugs see Chapter IV.

## IV. ADULTERATION OF VEGETABLE DRUGS.

### 1. INTRODUCTION.

Deception is a practice common to all callings, pharmacy being no exception, though it would seem that a profession which appeals so directly to the more altruistic motives would be free from fraudulent practice, but such is, unfortunately, not the case. Nor is it intended to imply that pharmacists are more dishonest than those engaged in other callings. It is, however, a fact that the temptations and opportunities for dishonest and criminal practice are greater in this calling than in most others. We cannot enter into a discussion of the various motives which lead to the practice of sophistication in pharmacy; suffice it to know that crude as well as powdered vegetable drugs are frequently placed upon the market variously adulterated. In some instances adulteration is the rule rather than the exception, as in the case of powdered elm bark and some spices. In recognition of such facts it becomes highly important that the practicing pharmacist should have the training requisite to the detection of such fraudulent work.

Naturally, those who market adulterated drugs take great care to conceal the fraud, and in this the misplaced ability of the unscrupulous is pitted against the intelligence of the trained pharmacist, whose duty it is to detect and expose such crooked work. The uneducated and inadequately qualified pharmacist is wholly defenseless against the criminal practices of the unprincipled collector, dealer and jobber, and he should accordingly be excluded from the profession.

Some drugs lend themselves more readily to sophistica-

tion than others. Powdered vegetable drugs are more readily and more generally adulterated than crude drugs. In some instances the fraud is quite readily detected while in other instances great skill and careful investigation are necessary to detect the deception.

It is evident that with the progress in pharmaceutical education adulteration decreases and the methods become altered in accordance with such progress. Crude methods of common practice in the past are supplanted by more scientific modern methods. With these introductory statements we shall now enter into a brief consideration of the more common forms of adulteration, the more common substances employed and outline the more suitable methods of detecting them.

### 2. ADULTERATIONS AS TO INTENT.

Not by any means all of the drug adulterations are premeditated and many never become known, that is an adulteration does not always imply criminal intent. As will be seen, ignorance plays a very important part in unintentional sophistication and this indicates very clearly the necessity of employing technical skill in securing pure medicinal substances for the relief and cure of disease.

#### *a. Unintentional or Accidental Adulteration.*

This form of adulteration is by no means uncommon and is due to ignorance and carelessness. In some instances it is wholly free from blame but in other instances the ignorance is so marked and the carelessness so evident as to deserve as much condemnation as intentional deception. The following are the principal causes of this form of sophistication:

1. Ignorance on the part of collectors who gather the wrong plant or mix the genuine drug with worthless material. This particular form of sophistication is not very com-

mon, as collectors, native and others, usually select the right drug instinctively. Such errors are generally made by new and inexperienced collectors, but these soon learn to avoid such mistakes; furthermore they are quite generally properly instructed by the experienced collectors.

A much more fruitful source of sophistication is carelessness on the part of collectors. Roots and rhizomes are hurriedly and carelessly gathered, an excessive amount of soil is left clinging to them along with undesirable plant parts, and the roots, leaves, branches, etc., of smaller foreign plants. This applies particularly to the roots and rhizomes collected in America which are, as a rule, also carelessly dried. Again collectors are not adequately instructed as to how and when to collect. Drugs collected out of season or carelessly dried are more or less worthless. To avoid this, collectors should be more definitely instructed by competent authorities.

2. Ignorance on the part of botanists who fail to distinguish between related species and varieties. Drugs from two wholly distinct species or varieties, one of which is more or less worthless, are supposed to be indentical and are placed upon the market variously intermixed. Again in a number of instances the botanical origin of the drug yielding plant is wholly unknown as with sarsaparilla, coto bark and some cinnamons. This form of sophistication was more common in the past. The leading authorities are often uncertain regarding the exact influence of climatic conditions, cultivation, etc., as already indicated and this is often responsible for an inferior quality of the drug.

3. Ignorance on the part of the practicing pharmacist. As indicated in the introduction, if the pharmacist does not have an adequate pharmaceutical training he is wholly at the mercy of unscrupulous jobbers who will sell him their worthless material, reserving the genuine wares for the

intelligent pharmacists, who cannot be duped so readily. The ignorant pharmacist will frequently purchase a cheap drug, especially powdered drugs and spices, under the impression that he is getting a first class article at a bargain. The ignorant pharmacist is also liable to use and sell material which has become worthless through age, exposure to moisture, contamination with bacteria, hyphal fungi and other parasites.

4. Exaggeration and untrustworthy work of analytical chemists who claim to have discovered medicinal substances which do not exist at all, or only in small quantities. This is usually the case when some new remedy is vaunted. This form of sophistication is unintentional in so far as inherent human enthusiasm naturally leads to more or less exaggeration. It has little effect with the intelligent pharmacist and physicians, as they will not recommend or use a drug until it has been thoroughly tested by competent and unbiased chemists and physiologists.

### *b. Intentional or Criminal Adulteration.*

This form of adulteration is due to an utter lack of conscience. Foreign substances are added to the salable drugs with a view to deriving a pecuniary profit above that which comes from dealing in the genuine article. Every housewife knows that powdered spices, as pepper, cinnamon, allspice and cloves are subject to adulteration. This is of such common occurrence that it is advisable to purchase the whole spice and grind it at home. The pharmacist should apply this suggestion to vegetable drugs in so far as that is possible. The following are the more common methods and sources of criminal adulteration:

1. Intentional adulteration by collectors. The prime motive may spring from a scarcity of the drug; an effort is therefore made to bring the quantitative supply to the normal by adding worthless material or inferior grades.

Again the quantitative supply may not be deficient but inordinate greed on the part of the collector leads to the addition of some adulterant for the purpose of increasing the bulk.

2. Intentional adulteration by dealers and jobbers. (a) Dealers may purchase inferior grades of collectors and sell them as first-class articles to ignorant retailers or pharmacists. This is a very common practice. (b) Foreign material is added to the drug and sold at a price below that of honest dealers or, (c) The dealer may maintain the price while furnishing additional bulk to be sold over and above the amount sold by honest competitors.

3. Intentional adulteration by practicing pharmacists. This is of comparatively rare occurrence, as the pharmacist soon learns that such practice injures his trade. The alert and competent members of the medical profession, who have the direct interest of the sick at heart, make such criminal practice almost impossible.

4. Intentional fraudulent testimony by scientists (botanists and chemists), who claim to have discovered some new useful drug. This likewise is of rare occurrence, as the fraud is promptly exposed by honest authorities.

Of these criminal practices it is the middleman, dealer, or jobber who is most likely to prove the guilty party. The collector is closely supervised by the dealer, who will generally insist upon a genuine article, but will attempt to palm off inferior or worthless material on the retailer. It is therefore largely the intelligent practicing pharmacist who must assume the responsibility of purifying the drug trade.

### 3. MANNER OF ADULTERATION.

The adulterants added to vegetable drugs vary greatly as to kind and quantity. In some instances the foreign substance is added in comparatively small quantities so as

to prevent ready detection; in other instances large quantities are added, and again there may be complete substitution. We may therefore recognize partial substitution and complete substitution.

### *a. Partial Substitution.*

This form of sophistication is most commonly practiced, the intention being to retain the apparently normal identity of the drug. The sophisticant must therefore not be added in large quantities, otherwise the fraud is too readily detected. The amount added will depend somewhat upon the judgment and intelligence of the sophisticator. If he fears the detective powers of the qualified pharmacist he will refrain from his crooked work entirely or will add only small quantities (one to five per cent); if he is convinced that the pharmacist is ignorant and lacking in ability he will not hesitate to add as much as fifty per cent or even more. It is generally quite difficult to estimate the amount of the sophisticant added. In the case of crude drugs it would be necessary to go through the entire collection and carefully winnow out the foreign substance or substances. This is a tedious task, but the results are quite accurate. In the case of powdered drugs the matter becomes much more difficult as has already been indicated, and as will be more fully explained in Chapter IV.

### *b. Complete Substitution.*

This form of sophistication is not commonly practiced with vegetable drugs, though it is not at all unusual in other departments of pharmacy. It is recorded that nutmegs have been made of wood; a reckless form of adulteration, said to have been extensively practiced in Connecticut, and which gave the state the sobriquet "Nutmeg state." Imitation coffee beans have been made of pressed clay; cloves of roasted and pressed starch. A mixture of tartar emetic

and some inert vegetable powder has been substituted for powdered ipecac, etc. But such crude substitution is not commonly practiced. It is more usual to substitute a closely related plant or plant part for the drug itself, whether in the crude or powdered state. For instance the western senega is substituted for the southern variety; one variety of cinchona for another, etc. In some instances total substitution may be due to a mistake, a misunderstanding or to ignorance. For example, safflower has been sold for saffron under the ignorant belief that it was the true Spanish drug.

### 4. MATERIAL EMPLOYED.

The material more usually employed in the adulteration of vegetable drugs may be divided into two groups; that added to crude drugs and powdered drugs and that which may be added to powders only. The material employed does not necessarily give any indication whether or not the sophistication was accidental or intentional, though in many instances it does give such evidence. For instance if willow leaves and poplar leaves are found with tea we may safely conclude that the sophistication was criminal, as even the most ignorant collector can distinguish between tea leaves and willow leaves. If starch or flour is found in a powder normally free from starch we may again safely conclude that the sophistication was criminal. The presence of the first year leaves of digitalis among the second year leaves may be wholly unintentional.

#### *a. Organic Substances.*

1. *Closely Related Plants and Their Varieties.*—This is the more usual material employed as in many instances the physiological action, the gross characters and histological characters are closely similar. In some instances, however, the gross characters may be similar while the histo-

logical characters are different and vice versa. For example, we find that *Apocynum cannabinum* and *A. androsaemifolium,* Surinam quassia and Jamaica quassia, resemble each other as to gross appearances, but the histological characters are quite different. *A. androsaemifolium* is distinguished from the other species by the presence of stone cells. The Surinam quassia differs from the other in the form of the medullary rays and the presence of stone cells in the bark.

2. *Remote Plants and Their Varieties.*—Not infrequently plants and plant parts having no close botanic relationship to the drug-yielding plant, are used as sophisticants, whether for crude drugs or powders. Sawdust is added to powdered vegetable drugs to increase the bulk. Remote plants and plant organs may be substituted for the drug itself because of a similarity in physiological action. Such adulterations are, as a rule, quite readily detected.

3. *Refuse and Winnowings.*—These are usually powdered and added to the pure article or sold separately. The refuse and winnowings of spices, pepper in particular, are quite generally used as indicated. This will explain why it is possible for some dealers to sell ground spices and other vegetable powders at a price much below that of the market value of the genuine crude drug itself. The fraud is not by any means easily detected, because the histological characters of the refuse and winnowings are the same or similar to those of the pure article. Giving careful attention to weight, color, odor and taste will generally disclose the fraud, especially when combined with a thorough microscopical examination.

4. *Exhausted Drugs.*—Exhausted drugs, whether crude or powdered, are not infrequently redried and again placed upon the market, generally after being mixed with the pure article. This applies for instance to tea, ground coffee, ex-

pressed cloves and other powdered drugs and spices, and other medicinal substances. In some hotels and tea-houses where tea is used in large quantities the exhausted leaves are collected, dried and rolled with good tea and placed upon the market. Coffee grounds are collected, dried and mixed with good ground coffee. Exhausted powders are taken from the percolators, dried and mixed with pure powders.

5. *Inferior Drugs.*—Drugs having become more or less worthless through infection with vegetable and animal parasites, through age, exposure to moisture and sunlight, etc., are sold as genuine or mixed with the genuine. Drugs more or less worthless because collected out of season, improperly cultivated, carelessly dried, etc., are also placed upon the market. Such drugs are generally sold in the powdered state, as that renders detection more difficult. In the case of crude inferior drugs careful attention should be given to color, odor and taste, as compared with the pure drug. A careful chemical test may prove useful, as alkaloids and other active constituents are greatly reduced in such drugs.

6. *Starches and Meals.*—These substances are added to powdered drugs only. Starch and flour have ever been extensively employed in drug adulteration. They are cheap, plentiful everywhere, easily obtained and perfectly harmless. The modern sophisticant must, however, be very cautious in their use as the cheaper and more common starches and meals have characteristic granules and are therefore readily detected and identified microscopically. If starch is added to a drug which is normally free from starch, the fraud is detected at once. Various cereal meals are generally employed, as wheat flour, corn meal, oat meal, etc. Occasionally the flour or starch is partially

roasted. This renders it less conspicuous because of its whiteness and partially dextrinizes the starch granules, thus rendering their detection more difficult. Meals free from starch are occasionally employed in the adulteration of vegetable powders, especially almond meal.

Some powdered drugs are so commonly adulterated that dealers boldly assert that a pure article does not exist; this applies for instance to powdered elm bark which is quite universally adulterated with starch and flour. Kamala is quite generally adulterated with colored starch and sand. Such substances as powdered pepper, cayenne pepper, and mustard are quite frequently adulterated with considerable quantities of flour.

7. *Insects and Insect Remnants.*—These are perhaps never added intentionally. They are very frequently accidentally present in some drugs, as leaves, flowers and barks. The insects cling to or are retained by the various plant parts where they die and are collected with the drug. Aphidae (plant lice) are very plentifully found with the strobiles of humulus. In all such instances the organisms are dead and need cause no concern as they are rarely, if ever, present in sufficient numbers to injure the value of the drug. They are mentioned here because students are apt to find occasional insects and insect remnants in the microscopical examination of drugs. The presence of living insects and other animals is evidence that the drug is attacked by a destructive parasite and should be promptly attended to.

### *b. Inorganic Substances.*

1. *Sand.*—This substance is added to powdered drugs and it is surprising to find how extensively it is used. It must, however, be kept in mind that a small amount of sand is normally present in many drugs. Air currents carry dust and sand particles to all exposed parts of plants; it accumu-

lates in crevices of barks and other irregularities of plant surfaces; it is readily retained by waxy and resinous excretions of leaves, flowers and fruits; it is retained by trichomes, etc. Soil, which is simply a mixture of sand particles and decayed organic matter, clings to all subterranean plant organs. From these considerations it becomes evident that some sand will be found upon many crude drugs and mixed with the powders made from them, as there is no means of removing it entirely even with the most careful washing and winnowing. We would naturally expect to find more normal sand with the powders of roots, rhizomes and tubers; less with barks and still less with most herbs, flowers and fruits. It should be wanting in powders of peeled barks, of woods, of peeled roots, rhizomes and tubers, and seeds. I have found kamala and lupulin adulterated with considerable quantities of fine sand.

2. *Dirt, Clay, Lime.*—Not infrequently collectors leave enough dirt attached to subterranean plant organs as to amount to adulteration, as for instance Mexican sarsaparilla and many of the roots and rhizomes collected in the United States. Clay is sometimes added to powders (goa powder). Lime is not intentionally added, but it will be found in powders made from limed crude drugs as iris, ginger and nutmeg.

3. *Pebbles, Lead, etc.*—Such substances are not commonly employed and are nearly always added to crude drugs. Pebbles are often added to coffee beans. Shot, pebbles, lead foil, etc., have been found in the interior of lumps of gum opium. Stones have been found in the interior of bundles of sarsaparilla and other bundled crude drugs, but this is of rare occurrence.

4. *Coloring Substances.*—The desire to place an attractive article upon the market has led to the pernicious habit of coloring certain drugs. We have already referred

to the habit of liming which does serve some useful purpose besides giving a white color. In certain parts of China, tea is quite generally colored with indigo and Prussian blue. Coffee beans are similarly colored. Adulterants are often colored before adding them to the drug in order to simulate the normal color. In some countries the little cubes of different kinds of medicinal woods are variously colored.

The habit of coloring drugs for the purpose of simulating a better grade of the article should be looked upon as criminal adulteration, even if the coloring substance is perfectly harmless.

### 5. THE DETECTION OF ADULTERATIONS.

The ability to detect adulterations of vegetable drugs will depend upon the skill and training of the pharmacist. The student must acquire the ability to recognize all of the gross characters and the histologic characters of each drug. It will thus be possible for him to recognize the absence or presence of foreign substances without the least difficulty.

The practicing pharmacist should never take the purity of an article for granted, but should satisfy himself to that effect personally. Every drug as soon as received should be inspected carefully to determine whether or not it is the drug intended, as some mistake might have been made in packing, labeling and shipping, though that is of rare occurrence. The drug should then be carefully examined to determine its purity and quality and in order to do this the pharmacist must be thoroughly familiar with the characters of the normal drug. We have elsewhere referred to the methods of examining drugs and need not refer to them again. If the drug does not possess the qualities of a first-class article it should be returned to the shipper at once with a suitable condemnation.

In the case of powdered drugs the matter becomes more

difficult. The intelligent use of a good compound microscope is absolutely necessary. The student must have a thorough knowledge of vegetable histology. He must have the ability to recognize the normal tissue elements in order that he may recognize the presence of foreign elements. The recognition of the adulterant is of prime importance; its identity is of little significance in most instances. In many cases it will be found very difficult if not impossible to determine the identity of the sophisticant. The quantitative determination of the sophisticant is also quite difficult. Approximate determinations may be made by examining a number of slides and estimating ocularly the comparative amount of adulterant and drug. In some instances the adulterant is detected with great difficulty, as for instance in the case of exhausted powders, winnowings, etc., as already indicated. Starches and meals are as a rule readily detected with the exception of rice starch. Rice starch consists of small granules, irregular in form, and might readily be overlooked for the smaller granules normal to the powder, unless added in large quantities.

Sand is quite readily detected. It produces a very characteristic gritty sensation under the cover-glass and to the teeth when the drug is tested for its taste. The beaker test is very simple and reliable. Mix a known quantity of the powder in a beaker of water; the powder will float while the sand will settle to the bottom, decant the water with the powder repeatedly and finally measure and weigh the sand and compare with the quantity of powder used.

Nothing further need be said about the detection of organic adulterants. In the following chapter are given some suggestions on the microscopic examination of vegetable drugs which also have application to the examination of adulterated material.

# CHAPTER IV.

## THE HISTOLOGICAL EXAMINATION OF VEGETABLE DRUGS.

### I. INTRODUCTION.

As already indicated the identification of vegetable drugs and their adulterants will depend largely upon the intelligent use of a good compound microscope and the necessary accessories and reagents. As a necessary preliminary education the student should have adequate instruction in general vegetable histology so that he may recognize the various cell-forms and cell-contents readily.

It is further evident that the study of the histology of crude drugs is a necessary preparation to the study of these drugs in the powdered state. In the powders the cells and cell-contents appear variously intermingled and broken. This fragmentary occurrence of tissue elements renders their identification more difficult as compared with the study of these elements as they appear in carefully prepared sections of crude drugs.

Nothing shall be said of the methods of micro-technique pertaining to the histologic study of crude drugs, as that belongs to the course in vegetable histology. A few suggestions on the microscopic examination of powdered vegetable drugs will be found useful.

As already indicated, the fineness of the powders varies greatly. For examination under a compound microscope Nos. 60 to 100 are most suitable. No. 80 is perhaps the fineness best suited in the great majority of cases. A No.

100 is rather fine and a No. 60 is somewhat coarse. Very coarse powders must be further reduced by means of a pestle and mortar.

For microscopic examination a pinch of the powder is mounted in some clearing fluid. Heat may be employed to remove air bubbles and to increase the translucency. The student is at first greatly confused by the optical picture which presents itself. Cell fragments and cell-contents are variously intermingled with various cell-groups, but this confusion vanishes with experience and with the knowledge of the histologic character of plants. With the exception of very fine meals it will be found that cells occur in groups, the number of cells in each group depending upon the fineness of the powder and the size of the cells. Bast cells, tracheids, wood cells, ducts and other elongated elements appear in longitudinal view. Tabular elements, as epidermal cells, appear in surface views. The more delicate elements, as meristem cells, leaf parenchyma, pith cells, ordinary isodiametric parenchyma, are usually pretty well broken up. Sclerenchyma cells are rarely broken and belong to the strikingly characteristic elements noticeable in powders; the same may be said of the short thick bast cells found in cinchona, cinnamon and some other drugs. Hair cells, epidermal cells, and pollen-grains are quite diagnostic. Glandular structures are of little significance in the examination of powders as they are usually too much broken. Cell-contents are very important, especially the starches and the crystals of calcium oxalate. Starch granules usually appear entire, likewise the crystals of calcium oxalate excepting the large prismatic crystals as they occur in scilla and a few other drugs.

It is rarely desirable or necessary to use many microchemical reagents in the study of vegetable powders. An

intelligent use of a few suitable clearing fluids[1] and a solution of chloriodide of zinc is about all that will be required. A concentrated solution of potassium hydrate and sulphuric acid may prove useful as some drugs give characteristic color reactions with these reagents. Fehling's solution may be found useful in developing the sugar reaction. It is not advised that the student should attempt micro-chemical tests for vegetable alkaloids and glucocides as they are difficult, unreliable and not yet carefully worked out.

The following is a tabulation of the color reactions of the different vegetable elements with chloriodide of zinc. A drop of the reagent is to be added to the section or pinch of powder and examined immediately in order that all of the color changes may be noted.

I. Cell-walls.

1. Cork.—No reaction.
2. Epidermis, not suberized or lignified.—Reaction as for parenchyma.
3. Parenchyma.—A gradual change from reddish brown to deep violet. Reaction may require several hours to develop fully. Reaction due to cellulose.
4. Bast.—As for parenchyma. Reaction more rapid.
5. Collenchyma.—As for bast.
6. Sieve tissue or phloem.—As for bast. Reaction more rapid.
7. Lignified cells[2] (tracheids, vessels or ducts, wood cells, some bast, sclerenchyma and other ligni-

[1] A mixture of equal parts of glycerin and water will be found most useful.

[2] The best lignin reaction is obtained by adding a drop of 2 per cent alcoholic solution of phloroglucin, followed by a drop of hydrochloric acid. A bright red reaction develops rapidly.

fied elements).—Reddish brown reaction, which gradually deepens. Reaction due to lignin.

II. Cell-contents.

1. Starch.— As for parenchyma. The reaction is, however, so rapid that the reddish brown coloration is rarely noticeable.
2. Protoplasm and proteids.—Reddish brown.
3. Tannin globules.—Reddish brown.
4. Laticiferous fluid.—Wine red.
5. Amylodextrin granules.—Reddish brown.
6. Crystals.—No reaction.
7. Oils and fats.—No reaction.
8. Resin and waxes.—No reaction.
9. Mucilage and gums.—No reaction.
10. Sugar[1] and inulin.—No reaction.

## II. TABULATION OF HISTOLOGICAL ELEMENTS.

The following arrangement of plant organs with their characteristic tissues and tissue elements will be found useful and suggestive in the critical histologic examination and study of crude drugs and powdered drugs.

I. Leaves.

$1^1$ Epidermal elements.—By far the most important diagnostic elements of the leaf.

$1^2$ Upper epidermis.

$1^3$ General outline of cells as determined from an examination of transverse and surface sections.

[1] To test for sugar heat moderately thick sections or a pinch of the powder mounted in Fehling's solution until bubbles escape. A dirty reddish brown precipitate is formed within the cells containing sugar.

2[3] Measurements. Size of cells sometimes diagnostic.

3[3] Cuticle.
- 1[4] Thickness. Very variable.
- 2[4] Surface markings. Linear, warty, none.
- 3[4] Surface deposits. Resinous, waxy, none.

4[3] Vertical walls. In vertical view.
- 1[4] Thickness. Not excessively variable or characteristic.
- 2[4] Form. Wavy or straight; often a diagnostic comparative feature.
- 3[4] Porosity of walls.
- 4[4] Nodular thickenings. Characteristic when present.

5[3] Cell-contents. Not commonly present or plentiful
- 1[4] Chlorophyll. Usually wanting, not characteristic.
- 2[4] Starch. Very rarely present.
- 3[4] Crystals. Not common, diagnostic on occasion.
- 4[4] Inulin and hesperidin. Plentiful and diagnostic in a few instances (Buchu).
- 5[4] Coloring matter, resin, wax.
- 6[4] Tannin, etc.

6[3] Hair cells (trichomes). Very important and diagnostic.
- 1[4] Nonglandular.
  - 1[5] Simple.
    - 1[6] Single-celled.
      - 1[7] Size. Rather variable.
      - 2[7] Form. Sometimes diagnostic.
      - 3[7] Thickness of walls and exterior markings.
    - 2[6] Many-celled.

$1^7$ Number of cells.

$2^7$ Size, form, etc., as above.

$2^5$ Aggregate or stellate. Quite characteristic and diagnostic.

$1^6$ Number of cells.

$2^6$ Form and relative position of cells.

$3^5$ Branching. Quite characteristic.

$1^6$ Number of cells.

$2^6$ Size and form of cells.

$3^6$ Number of branch cells.

$2^4$ Glandular. Usually few, small and quite indistinct. Sometimes diagnostic

$1^5$ Neck or basal cells; size and number.

$2^5$ End or secreting cells; size and number.

$3^4$ Neighboring cells.

$1^5$ Number. Sometimes diagnostic.

$2^5$ Size and form. Radially elongated.

$4^4$ Contents. Usually none in nonglandular hair-cells; when present, quite diagnostic. (*Cannabis Indica*).

$5^4$ Color and external markings.

$7^3$ Stomata. Often wanting. For characteristics see Lower Epidermis.

$2^2$ Lower epidermis. Make careful comparisons with upper epidermis.

$1^3$ General outline of cells.

$2^3$ Measurements. Transverse diameter usually somewhat more than that of upper epidermis. Vertical diameter usually less.

$3^3$ Cuticle. Usually thinner than upper. Characteristic thickenings.

$4^3$ Outer wall. Sometimes with diagnostic modifications. (Coca leaves.)

$5^3$ Vertical walls. More generally wavy in outline than those of upper epidermis.

$6^3$ Hair cells. Usually much more numerous than upper epidermis. (See upper epidermis.)

$7^3$ Stomata*. Nearly always present. Vertical or surface view to show the striking structural characteristics.

$1^4$ Number. Variable, but not diagnostic, excepting when comparing upper and lower epidermis.

$2^4$ Size (of guard cells). Somewhat variable, but rarely diagnostic.

$3^4$ Guard cells. Difficult to see in leaves with thick cuticle, as in eucalyptus.

$1^5$ Form. Constant in vertical view; variable in profile view. Not diagnostic.

$2^5$ Contents. Chlorophyll and occasionally coloring matter.

$4^4$ Nebenzellen.† Sometimes quite characteristic. Compare carefully with normal epidermal cells.

$1^5$ Number to each stoma. From two to five or six. Number sometimes diagnostic.

$2^5$ Variations in size. Sometimes diagnostic. (senna).

$3^5$ Markings (cuticular). Sometimes quite different from those of normal epidermal cells.

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* When stomata are wanting in one epidermis it indicates the upper. When present on both sides it will be found that they are quite generally more numerous on the lower epidermis.

† The English equivalent for this German term is neighboring cells.

$4^5$ Outer wall of cells. Sometimes quite different in form from normal cells (coca).

$5^5$ Contents. Sometimes diagnostic (some species of jaborandi).

$5^4$ Air chamber. Never diagnostic. Crystals of calcium oxalate usually more numerous in the spongy tissue cells bounding the air chamber.

$2^1$ Hypodermal elements. Usually wanting and rarely of any significance, especially in powders.

$1^2$ Upper hypoderm.

$1^3$ Size and form of cells. Larger than those of lower hypoderm.

$2^3$ Number of cell layers. Usually two.

$3^3$ Cell walls. Colorless and comparatively thin. Mucilaginous in buchu.

$4^3$ Contents. Usually empty.

$1^4$ Cystoliths in large cells (Ficus).

$2^4$ Mucilage.

$3^4$ Crystals of calcium oxalate.

$2^2$ Lower hypoderm. Compare with the upper.

$3^1$ Palisade tissue. Never characteristic in powders.

$1^2$ Size and length of cells.

$2^2$ Rows of cells. One to three.

$3^2$ Contents.

$1^3$ Chlorophyll.

$2^3$ Crystals. Not usual.

$4^1$ Spongy tissue. Rarely characteristic.

$1^2$ Form of cells.

$1^2$ Oval and elongated.

$2^3$ Branching.

$2^2$ Contents.

$1^3$ Coloring matter. Not usual.

$2^3$ Crytsals. Prismatic and aggregate.

$3^3$ Resin, wax, inulin, tannin.

$4^3$ Chlorophyll.

$5^1$ Stone cells in leaf parenchyma. Rare but diagnostic (tea).

$6^1$ Mechanical cells. Usually not diagnostic. (Eriodictyon, lateral lines of coca).

$7^1$ Glands. Not characteristic in powder.

$1^2$ Form.

$2^2$ Contents. Resin, wax, coloring matter.

$3^2$ Number.

$4^2$ Position in leaf parenchyma.

$8^1$ Leaf stalk (petiole). Structure usually not characteristic, similar to that of stem.

$1^2$ Epidermis. See above.

$2^2$ Cork cells.

$3^2$ Parenchyma with cell-contents, as starch, crystals, resin, coloring matter, etc.

$4^2$ Stone cells (sclerenchyma). Sometimes diagnostic.

$5^2$ Vascular tissue.

$1^3$ Bast.

$2^3$ Tracheids.

$3^3$ Vessels. Occasionally characteristic.

II. FLOWERS.

$1^1$ Staminate structures.

$1^2$ Vegetative tissue elements. Not characteristic, diagnostic or distinct.

$2^2$ Pollen grains. Very important and diagnostic.

$1^3$ Size. Not very variable.

$2^3$ Form. Quite variable and characteristic.

$3^3$ Color. Mostly yellowish brown.

$4^3$ Markings of exine. Characteristic and diagnostic.

$2^1$ Pistillate structures. Not diagnostic.

$3^1$ Petals.

$1^2$ Epidermal elements. Compare with leaf.

$1^3$ Structure and form. Hair cells.

$2^3$ Contents. Coloring matter.

$2^2$ Parenchyma. Deficient and not important.

$3^2$ Vascular tissue. Deficient and not diagnostic. (See leaf.)

$4^1$ Sepals. Compare with leaf. Quite important.

$5^1$ Pappus. Often diagnostic.

$6^1$ Stone cells. Usually from torus. Quite important and characteristic.

III. FRUITS AND SEEDS.

$1^1$ Epidermal elements. Special modifications of cells, often very characteristic and diagnostic. Compare with leaf.

$1^2$ Hair cells. Usually nonglandular and characteristic.

$2^2$ Stomata. Rare and not important.

$2^1$ Stone cells. Usually present. Often diagnostic.

$1^2$ Form and size. Variable.

$2^2$ Color. Reddish brown to nearly colorless.

$3^2$ Cell-walls.

$1^3$ Porosity.

$2^3$ Thickness.

$1^4$ Uniform.

$2^4$ Thicker on one side.

$3^1$ Special cells of testa.

$1^2$ Size and form. Often very characteristic.

$2^2$ Color.

$4^1$ Endosperm (parenchyma) cells.

$1^2$ Form and size.

$2^2$ Cell-walls.

$1^3$ Thickness. Quite variable.

$2^3$ Porosity.

$3^3$ Form. Usually quite regular; wavy, irregular.

$3^2$ Contents. Usually not diagnostic.

$1^3$ Starch. Absent or present. See starch under roots and rhizomes.

$2^3$ Proteid granules.

$3^3$ Amylodextrin granules.

$4^3$ Oils and fats.

$5^3$ Crystals.

$6^3$ Resin, wax, etc.

$5^1$ Vascular tissue. Not specially characteristic. Plentiful in pericarp. Deficient in seeds.

IV. Barks.

$1^1$ Suberized tissue or true cork.

$1^2$ Size and form of cells.

$2^2$ Contents.

$1^3$ Granular contents. Tannin.

$2^3$ Red or reddish brown coloring matter.

$2^1$ Lenticular structures. Like those of other plant organs. Not characteristic.

$3^1$ Bark parenchyma. Not diagnostic.

$1^2$ Size and form of cells. Usually loosely united. Sometimes much elongated.

$2^2$ Contents.

$1^3$ Crystals. Prismatic and aggregate.

$2^3$ Starch. Not plentiful or diagnostic.

$3^3$ Mucilage, resin, coloring matter, etc.

$4^1$ Collenchymatous parenchyma. Not common or very characteristic.

$5^1$ Ducts and glandular structures. Not important.

$6^1$ Bast fibres. Very important and diagnostic.

$1^2$ Occurrence.

$1^3$ Singly.

$2^3$ In groups.

$3^3$ Continuous concentric layers.

$2^2$ Size and form. Porosity of walls.

$1^3$ Typical.
$2^3$ Very large and short (cinchona).
$3^3$ Branching cells.
$3^2$ Contents. Some starch.
$7^1$ Crystal-bearing fibres accompanying bast and stone cells. Quite important and diagnostic.
$8^1$ Sclerenchymatous tissue.
$1^2$ Occurrence.
$1^3$ Singly.
$2^3$ In groups.
$3^3$ Continuous concentric layers.
$2^2$ Size and form.
$3^2$ Cell-walls.
$1^3$ Porosity.
$2^3$ Thickness.
$1^4$ Uniform.
$2^4$ Thicker on one side (cinnamon).
$3^3$ Color.
$9^1$ Medullary ray tissue. Radially curved.
$1^2$ Cell-forms. Porosity of walls.
$2^2$ Cell-contents. Starch and crystals.
$3^2$ Number of cell rows.
$10^1$ Epidermal. Quite generally wanting.
$11^1$ Chlorophyll-bearing parenchyma. Usually wanting in the older barks.

V. ROOTS AND RHIZOMES.

$1^1$ Epidermal elements. Usually not distinct or wanting.
$2^1$ Cork. Usually typical when present.
$3^1$ Parenchyma. Typical and well developed.
$1^2$ Form of cells.
$1^3$ Outer parenchyma tangentially flattened.
$2^3$ Inner parenchyma isodiametric.
$2^2$ Cell-contents. Very important.
$1^3$ Starch granules.

$1^4$ Simple.
$1^5$ Form and size.
$2^5$ Lamellation.
$3^5$ Position of hilum.
$1^6$ Centric.
$2^6$ Excentric.
$2^4$ Compound. In twos, threes and fours.
$3^4$ Aggregate, as in oats.
$2^3$ Crystals of calcium oxalate.
$1^4$ Crystal dust or powder. Rare.
$2^4$ Prismatic. Comparatively rare.
$3^4$ Acicular. Raphides. Larger and smaller.
$3^3$ Cysoliths. Rare.
$4^3$ Mucilage cells.
$5^3$ Resin.
$6^3$ Coloring matter.
$4^1$ Vascular tissue.
$1^2$ Endoderm. Cells sometimes diagnostic.
$1^3$ Size and form of cells.
$2^3$ Thickness of cell-walls.
$3^3$ Contents.
$2^2$ Ducts. All possible forms.
$3^2$ Phloem.
$1^3$ Sieve tissue with contents.
$2^3$ Conducting cells.
$4^2$ Parenchyma.
$5^2$ Bast.
$6^2$ Tracheids. Often important.
$1^3$ Size and form.
$2^3$ Size, number and form of pores.
$5^1$ Woody tissue. Variable in amount.
$1^2$ Wood fibres.
$2^2$ Tracheids.
$3^2$ Ducts. Note form, size and markings.

$4^3$ Medullary rays.
$1^4$ Size and form of cells.
$2^4$ Number of layers.
$3^4$ Cell-contents.
$5^3$ Cell-contents. Crystals, some starch, etc.
$6^1$ Pith tissue. Usually deficient.

VI. STEMS.

$1^1$ Epidermis. Usually present. See leaf.
$2^1$ Hypoderm. Not generally present. See leaf.
$3^1$ Chlorophyll bearing parenchyma.
$4^1$ Collenchyma. Usually typical. In interrupted patches.
$5^1$ Bast.
$6^1$ Parenchyma. See roots and rhizomes. Contents less plentiful and less characteristic.
$7^1$ Woody tissue.
$1^2$ Wood cells and tracheids.
$2^2$ Medullary rays.
$8^1$ Vascular tissue. See roots and rhizomes.
$9^1$ Sclerenchyma. See barks.
$10^1$ Pith. Usually present. Variable in amount.
$1^2$ Size and form of cells. Rosettes.
$2^2$ Cell contents. Mucilage, resin, starch.

VII. WOODS. SEE WOODY TISSUE OF STEMS.

$1^1$ Wood cells.
$2^1$ Ducts.
$1^2$ Size.
$2^2$ Number and size of pores.
$3^1$ Medullary rays. Important and often diagnostic. Study transverse, tangential and radial sections carefully.

VIII. PITH. SEE STEMS.

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